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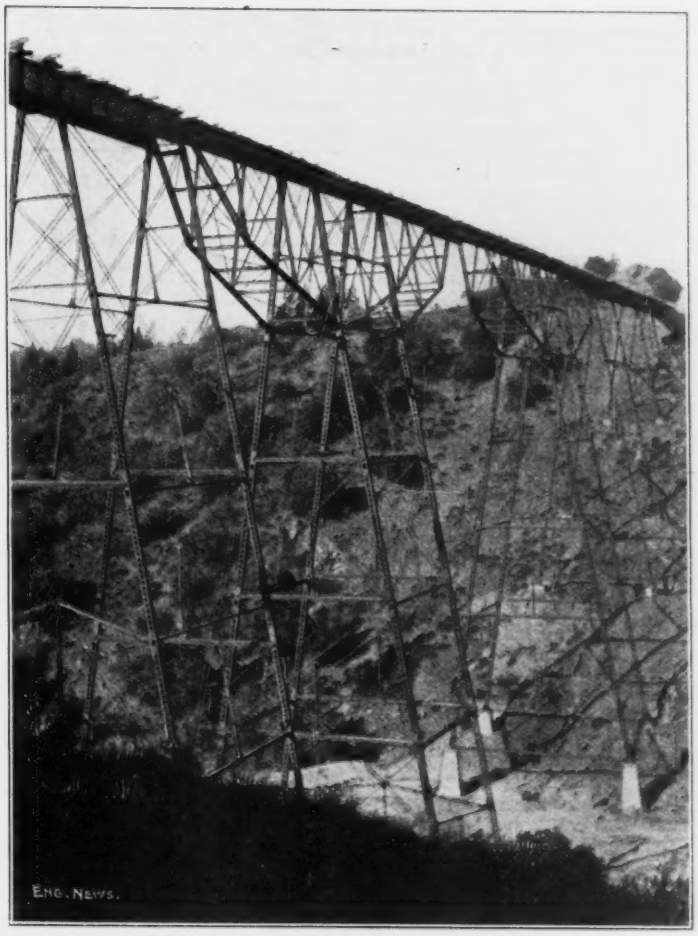
The Bear River Viaduct; Nevada County Narrow Gauge R. R., Colfax, Cal.

On a new cut-off of the Nevada County Narrow Gauge R. R., there has recently been completed across the Bear River, near Colfax, Cal., a viaduct which contains in the middle a double cantilever construction of somewhat novel design. The railway, which operates over about 30 miles of line, is at present only 3 ft. gage, but the possibilities of future traffic include a widening to standard gage, and the viaduct was built so as to accommodate such future extension. As originally designed, it was comprised entirely of the regular 40 and 60 ft. alternating spans, such as are shown at the right and left of the final structure in Fig. 2, but the owners of the mining claim at the river bed required at least a 150-ft. clearance there to allow for the passage of a gold-saving dredge, so the present long span constructed was adopted.

The viaduct is 810 ft. long and the base of rail is about 190 ft. above mean water in the creek. As can be noted in the figures, it consists of two central towers carrying outstanding cantilever arms and approached on either side by standard design alternate 40 and 60-ft. girder spans. All the towers have a constant transverse batter and are founded on concrete piers. They are composed of laced double-channel posts with horizontals and subverticals of laced double-angles and the diagonals of square rods with loop ends and turnbuckles. All intersections are pin connected. The girders are 5 ft. deep and 7 ft. c. to c. In design and construction they present no especial novelty.

Each cantilever is 160 ft. long, made up of a middle portion of two 20-ft. panels (practically an extension of the supporting towers) and, on each side, extended arms, containing three 20-ft. panels. The two trusses are in the battered plane of the tower bents. The lateral bracing in the upper plane of the trusses follows the same paneling as the main truss members, but in the plane of the lower laterals the outer two panels of each extended arm are each divided into two panels. The middle five of the vertical posts of the cantilever are also provided with extra lines of horizontal bracing.



VIEW OF THE COMPLETED BEAR RIVER VIADUCT.

Expansion is provided at each end of each cantilever span by pin and hanger connections. At the inner end of the cantilever where the suspended mid-span (the 30-ft. plate girder) connects the two cantilevers the expansion hanger shown in Fig. 4 is used. This comprises a pin in the end chord of the cantilever, carrying a plate which at its lower end carries another pin from which is hung the plate girder on an extended pin-plate. On account of the batter to the truss there is attached to the upper pin an eccentrically bored sleeve (Fig. 4) so that the plate girders can hang in a vertical plane. Where the cantilever joins the tower the expansion is cared for by a kind of rocker made with the built-up piece shown in Fig. 5, pin-connected at the upper end to the horizontal chord of the truss and at the lower end to an extended pin-plate attached to the top of the battered tower post.

The erection was accomplished by means of a cableway of 830 ft. clear span. A 2¼-in. steel cable was used with a sag of 40 ft. The steel was delivered on cars at the south end of the bridge, to which track had been laid and the first steel tower and the girders were placed and the track laid thereon before the balance of the steel was unloaded. The cars carrying the steel were then run out through the tower supporting the cableway upon the completed portion of way. The steel then was either erected as taken off or strung out on the ground near its final position in the bridge, to be picked up by the cableway and erected later. The tower legs, girders and top and bottom chords of the cantilevers were assembled in pairs on the ground and raised by means of a bridle so that the hoisting cables were always vertical. It was only necessary to swing the hoisting cable out of the vertical position to place the longitudinal struts and bracing in the towers, all other loads being perfectly balanced. As the cableway was the only means provided for handling the steel it was necessarily rather slow, but very economical. All of the steel was handled from the cars and erected and bolted to place by five erectors, including the foreman. This method of erection was adopted for two reasons: to avoid transporting nearly half of the steel around to the north end of the bridge and to avoid the necessity of taking down a heavy traveler with 100 ft. overhang after half the bridge was erected, transporting it to the other end of the bridge and rebuilding it to erect the other half of the bridge. The cableway after completing the work was as good as new while the traveler would have been practically useless. The steel arrived at the bridge on Aug. 26 and was all in place on Nov. 10.

The viaduct was designed to carry a live load equal to a train of 100,000 lbs. capacity standard-gage cars, but the present rolling stock is very much lighter (20-ton locomotive and 15-ton capacity cars). The tonnage of steel is about 480.

It was designed and built by the Shattuck-Edinger Co., San Francisco and Los Angeles, Cal., and the steel was fabricated at the Ambridge plant of the American Bridge Co.

Suggestions for the Conduct of Engineering Work in the Tropics.

By ROBERT BURGESS.*

Indications point to a considerable activity in the near future in railway building and other engineering enterprises in the Latin-American countries to the south of us, and promoters, railway companies, contractors and engineers who may be called upon to go to these torrid climates should profit by the experience, suffering and failure of those who have preceded them. The difficulties inherent in construction work in the tropics are due to three things: the inaccessibility, the political and social conditions and the climate of the country, and these three factors act directly upon the labor, making the latter probably the most important problem to be dealt with. Realizing the comparative scarcity of any reference book or article which would clear up any of the above difficulties, the writer is prompted to offer some conclusions drawn from six years experience in tropical countries, with the hope that they may be of some aid to those about to start on such work.

The discussion will take up in order the workmen, how to get them and how to care for them, methods and equipment and general suggestions in regard to relations with the natives.

The Labor Problem.

Do not hire white laborers in the United States, especially Irishman and other fair complexioned people, to do laboring work in the tropics. They will be a failure, except as foremen. Hire laborers, preferably in the following order: (1) the people who live in the country; (2) the people of the surrounding countries who can be induced or permitted by the authorities to come to the work. This labor is generally poor but cheap; they feed themselves, and work best by the task. However, in a large undertaking they will be found insufficient for not enough of them can be obtained; the Spanish republics are thinly settled and short of labor. They are needed at home, and are indisposed to go far from their families, or the place where they are born. The natives require careful treatment. In many respects they are only overgrown children, easily offended and discouraged, but loyal good workers when they have confidence in their employers and are treated with kindness and justice. The natives of the Latin countries are never satisfied long on any work, unless they can have their wives and children near them, so that they can be at home at least on Sundays. Otherwise after the first or second pay-day they are off for home, probably never to return. They should be encouraged to bring their families to the work. You will get better and longer service from them.

(3) Negroes and half-breeds in the over-populated West India Islands, such as Jamaica, Martinique, Porto Rico, Cuba, Haiti, etc. It may be possible to get men from Salvador, but that republic is overcrowded. The Jamaica negroes are the best laborers in the tropics. They stand the climate and are good workers, but it will not do to try to bully them. They are British citizens and will courageously defend their rights, and will appeal to the British Consul for protection, and will get it.

The American negroes would be good laborers in the tropics if they could be persuaded to go there. It would be a paradise for them in every respect. Those who advocate a return of the negroes to Africa, need not go so far. A much better country is Panama, or any of the Central or South American States. There is plenty of room, and colonies of blacks would be welcomed by the people and governments. The race prejudice against negroes does not exist there. They are given equal rights and privileges with other citizens. As agriculturalists they could easily make a good living with a minimum amount of labor. But the trouble is that you cannot persuade the American negroes to leave their white friends, neither do the whites want them to go. The Southern people need the labor of the negroes, and would not feel at home unless a few of them were always in sight. They would resent any attempt to colonize "their niggers."

(4) Laborers from the countries bordering the Mediterranean Sea—Spaniards, Italians, Greeks, Syrians.

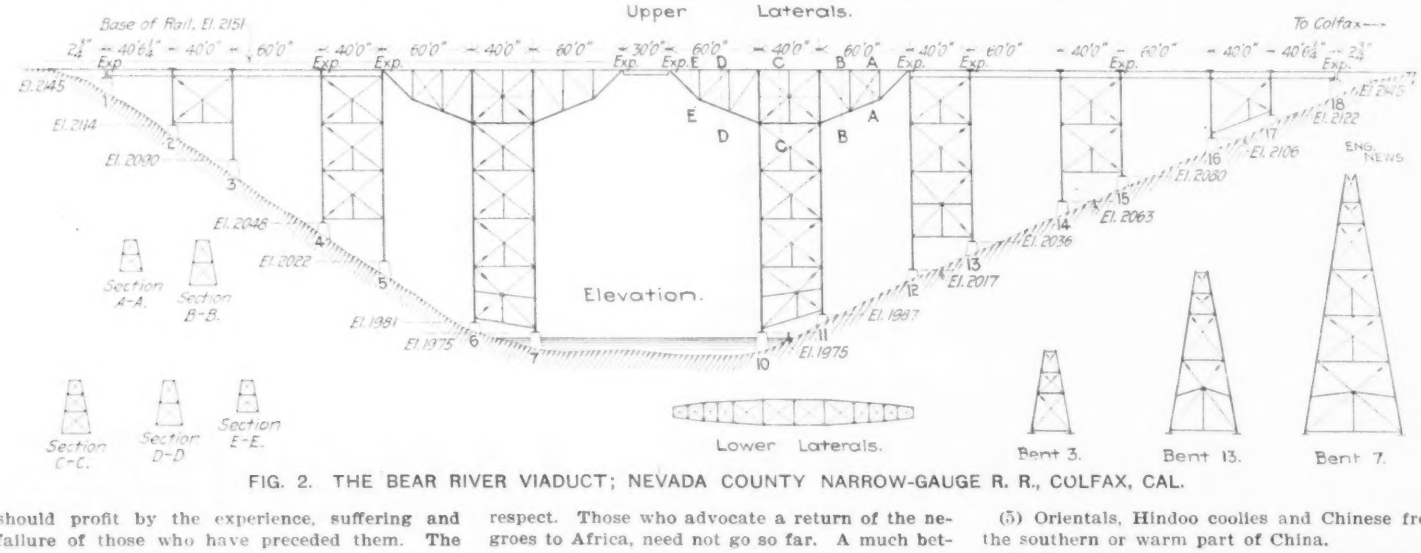


FIG. 2. THE BEAR RIVER VIADUCT; NEVADA COUNTY NARROW-GAUGE R. R., COLFAX, CAL.

(5) Orientals, Hindoo coolies and Chinese from the southern or warm part of China.

(6) The Philippine Islands are overpopulated. Possibly some good labor could be obtained there.

(7) Try the Japanese. Japan is overpopulated and is seeking an outlet for its surplus population. The average latitude of Japan is 35°. The climate is warmed by the Japan current. The people are intelligent, good mannered, energetic and thrifty. No doubt they would make ideal laborers and colonists in the tropics.

(8) Last of all hire laborers from Europe and the United States, preferring the dark-skinned and black haired, to the light skinned and fair haired.

In the above recommendations the writer wishes

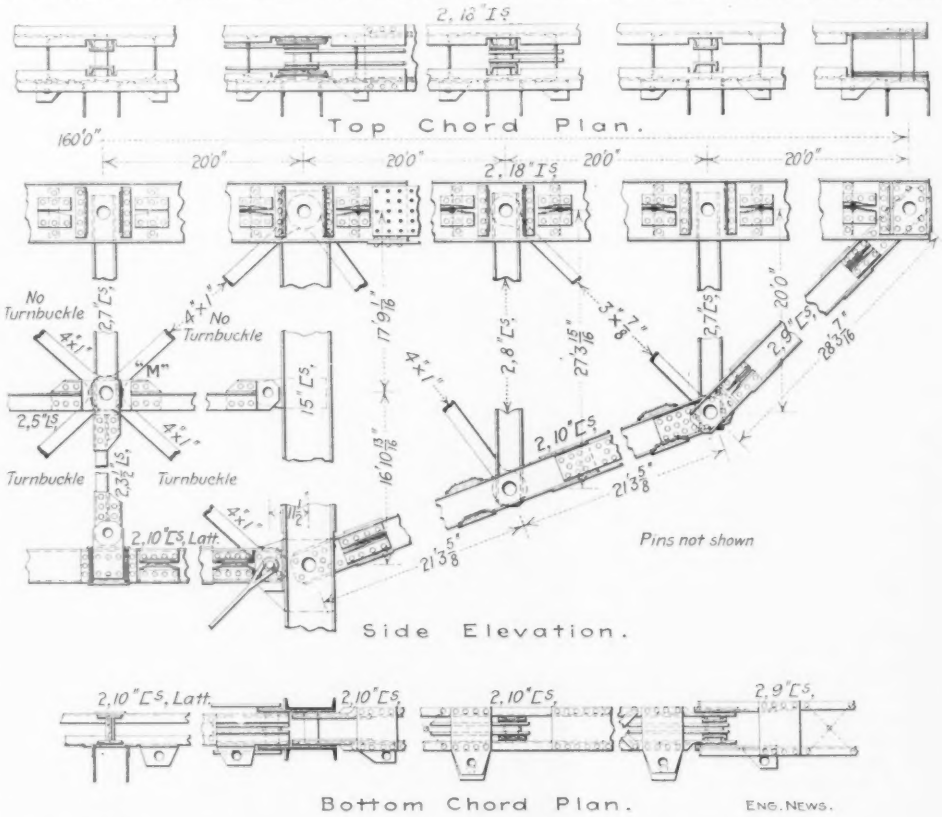


FIG. 3. DETAILS OF CANTILEVER SPAN.

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only to refer to the typically tropical regions, the low, flat, sea coast countries and interior plains lying less than 3,000 ft. above the sea, called by the natives "tierra caliente." Above that altitude any race can exist in health and comfort. Above

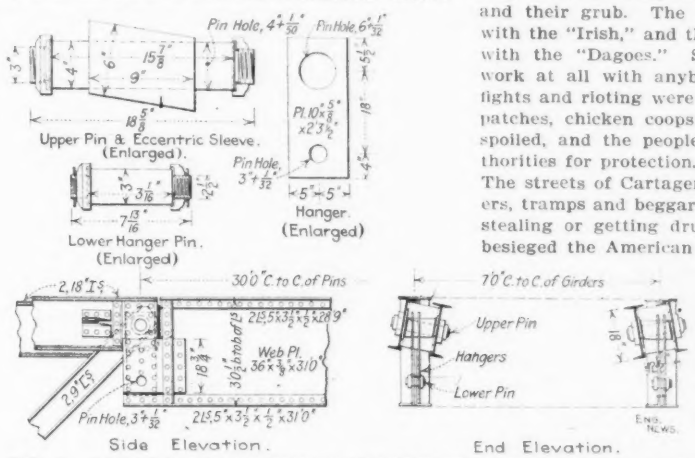


FIG. 4. DETAILS OF EXPANSION HANGER BETWEEN CANTILEVER ARM AND GIRDER.

8,000 ft., even on the equator, the writer has suffered more from cold at night than he ever did from heat by day.

An experience of the writer's in the importation of white laborers is interesting in this connection. Work on the Cartagena-Magdalena Railway (Colombia, S. A.) in 1893 had been dragging wearily. Not enough native labor could be obtained, although the company had sent out "man-catchers" into the adjoining provinces to bring them in. They would start for the railroad with perhaps 200 men, who had agreed to go, but would arrive with perhaps a dozen. The rest had deserted, a few at a time, and returned home.

The company then decided to import railroad laborers from the United States. They sent an

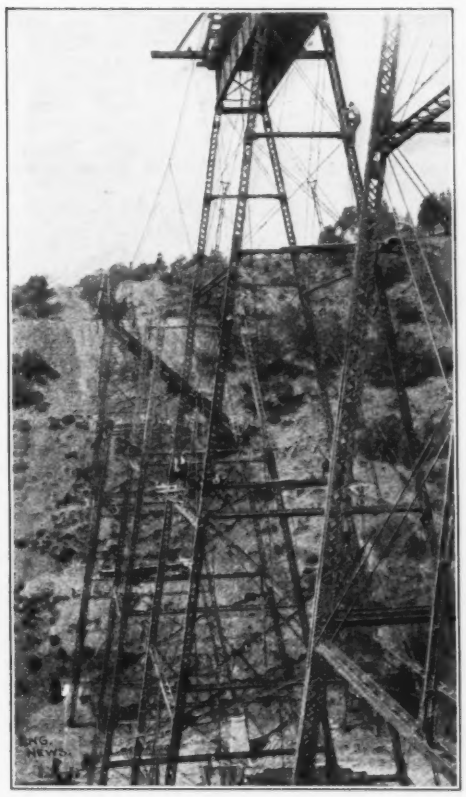


Fig. 6. View of Viaduct During Construction.

order to an agent in New York to send down 300 men. A steamer was chartered and the men were picked up in the streets of New York. There were some good railroad laborers among them, but a large part of them were the scum of New York, Bowery toughs, thieves, gamblers, men who had never done an honest day's work in their lives and never intended to. They took advantage of the free transportation to have a frolic. They were of all nationalities under the sun, except negroes and Orientals. Trouble began as soon as they arrived. They kicked about their quarters and their grub. The "Dutch" would not work with the "Irish," and the "Irish" would not work with the "Dagoes." Some of them refused to work at all with anybody. Petty thieving, fist fights and rioting were daily occurrences. Melon patches, chicken coops and corn fields were despoiled, and the people were calling on the authorities for protection. They began to stray off. The streets of Cartagena were filled with deserters, tramps and beggars. Some landed in jail for stealing or getting drunk and disorderly. They besieged the American Consul with terrible tales of their suffering and ill-treatment by the railroad company, and wanted to be sent home. He refused to aid them. Finally a semblance of order was obtained by separating the different nationalities in different camps. The force continued to dwindle. Some shipped away as sailors or stowaways to get out of the country. How they all got away will never be known.

The first thing that happened after their arrival was a strike among the native laborers when the latter found out that they were receiving smaller wages than the "Americanos," as they called them. They demanded the same pay. They were finally pacified, after all work had stopped for several days by agreeing to pay them $1.50 in their own money, which was more than they had been getting.

The New Yorkers had been hired at $1.50 gold per day. When their first monthly pay day came around the company attempted to pay them in native money, giving them, of course, an amount equal to the gold rate for which they had been hired. They refused to take it and all struck. They had hired for American gold and they were bound to have it. Several days were lost in this trouble. The company was willing to pay American money, but could not rake together enough in Cartagena to pay them. At last it was agreed that if they would take the native money this time and go to work, the company would send to New York for money and have it on hand for next pay day. This was done. $3,000 in gold, greenbacks and silver change down to nickels were brought down by the next steamer, and they were paid in the money they desired. Then they were in a fix. They could not spend it. The native storekeepers would not take it. They could not even buy a drink with it. Then to exchange their money they came around to the engineer and contractors, who commenced buying the American money at a big profit. Soon the storekeepers got wise and took it at a large discount on the regular exchange value.

At the end of six months, out of the 300 men sent down only 55 good Italian laborers were left working in the rock cuts. The experiment had been a failure, as all such will be unless great care is used in selecting the men. The company lost money by the experiment, the native wages had been raised and the work had dragged along as usual. In fact, it is bad policy to raise the wages of the natives, even for the purpose of stimulating them to increased effort. They will work less time, and in the end accomplish less. If they can earn as much in four days as they previously earned in six, they will lay off two days in the week. They never save anything. All they want is enough to live on, and have a good time on Sunday. If they have any money left over on Monday morning they will not go to work until it is spent.

IMMIGRATION.—It will pay promoters and railway companies to encourage immigration. Get liberal land grants and induce the people who go there to work to remain as settlers, even if you have to give them the land. The prosperity of a railway depends upon the number and wealth of the people along the line. Start an immigration bureau of your own and bring in agriculturalists from all nations; plant colonies; start industries of all kinds, saw mills, mining, raising cotton, which can be done as well there as in the Southern States. Open banana plantations which will produce as fine results in South America as in Central America and the West Indies. Develop the immense water-power; start cotton mills (white cotton cloth is almost the only dress of the masses of the people); start paper mills, the supply of fibrous plants is inexhaustible. Give enterprising men a lift and a "fair show," don't try to "hog" it all yourself. There is undeveloped wealth and room enough in South America to make everybody rich, who will go there for the next 300 years.

All races of men can there find a suitable climate, where they can live in health and comfort. The climate of a place depends upon the altitude, not the latitude.

SELECTION OF MEN.—Finally, in selecting men to be taken into the tropics:

Do not deceive any one as to the country, the climate, or the discomforts and privations he will have to endure. Hire a man who has had a tropical experience, other things being equal, in preference to a "tenderfoot."

Do not hire a man who makes his own salary, comfort and convenience the first, and often the only consideration. Hire honest, generous, conscientious men of good character, education and ability, men of a hopeful, cheerful disposition who are willing to take things as they come, and to endure and sacrifice for the success of the enterprise. Men should be well paid, but they should also feel a personal interest in the success of the enterprise, aside from the money they will get out of it.

Cut out the grouch, the crank, the kicker, and the man who is overfastidious about his dress

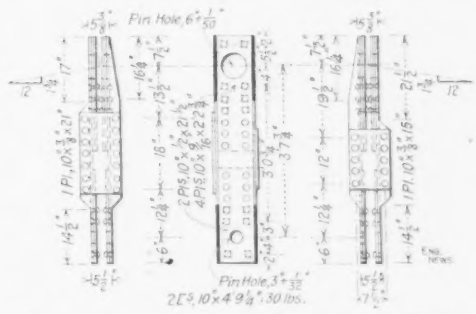


Fig. 5. Rocker Connecting Cantilever to Fixed Tower End.

and his eating. (The writer had two men in South America who would not eat chicken! they said it was a dirty animal.)

Cut out also the "booze fighter," and the man who invariably wants to display his loaded revolver in a crowd, and pass it round from hand to hand; also the man who, every time he gets a few drinks in him, flourishes his revolver, and shoots and yells. Such men are not only a nuisance, especially if they come into camp in the middle of the night raising a disturbance and waking everybody up, but they are dangerous. They might accidentally shoot somebody.

Select men who, among foreigners, will be a credit to their country, and for whom you will not have to apologize or feel ashamed.

Care of the Men.

After the right kind of workmen have been selected the next problem is their proper care on the work.

MEDICAL DEPARTMENT.—Tropical expeditions of the present day have a great advantage over those who have gone before. Malaria and yellow-fever have been called the "scourges of the tropics." But for them, the torrid zone, so called, would be more thickly inhabited and more prosperous than the rest of the globe. Nature there is kind and generous. The heat is no greater than we frequently endure in the United States, the only difference being that it continues all the year round. The soil is fertile. The mountains and streams are rich in mineral

wealth. Food is plentiful and easily obtained. Life can be sustained with a minimum of labor. Clothing is only required for decency's sake. The forest and fields furnish products which all the world needs and desires, coffee, chocolate, rubber, cotton, sugar, cocoanuts, bananas, oranges, lemons, etc.

Now that medical science has conquered malaria and yellow-fever, no one need fear to enter the tropics, if they live there under proper medical control and supervision. Witness the triumph of the United States medical service in Cuba, the Philippines and Panama. Their methods should be an example to the promoters of all large undertakings in the tropics.

It may be argued that a private corporation cannot afford to do what the United States Government has done. On the contrary, I take the view that no company can afford to do otherwise, than to take advantage of the advanced medical skill of the present day, in dealing with heretofore unhealthy regions. This may be the one item that will differentiate between failure and success. The long list of past disasters, the loss of human life and great treasure, shows what is to be expected, unless new and modern methods are employed. Leaving out of the question humanity and the value of human life as a business proposition, no company can afford the delays, ineffectual work, scarcity of labor, loss of valued and experienced men, continued running expenses long drawn out, loss of interest on the money already expended, loss of prestige and credit, final failure of the enterprise and bankruptcy.

Better good management, careful preparation for all contingencies, brain work instead of bull-headed trust to luck. Establish at the beginning an adequate medical department. Before any great amount of work is undertaken, prepare for the proper sanitary and medical care of the employees. Do this before they arrive in large numbers. Pattern after the work done at Panama. Clean up the adjoining country, abolish the breeding places of mosquitos. Build comfortable and sanitary buildings and camps. Screen every house. Provide every man with a mosquito bar and see that he uses it. As soon as a man is attacked by fever, isolate him in a properly screened hospital building. Have adequate hospital buildings erected before there are any patients to occupy them. Supply them with everything necessary for the relief and comfort of the sick, doctors, nurses, medical supplies, proper food, and appliances of all kinds.

Every locating party should have a physician attached as a member of the corps. He should not be a mere ornament, when his professional services are not required. It should be understood that he is to do any other work that may be necessary or convenient. He should act as camp steward, look after the supplies, the cooking, the care and sanitation of the camp, act as purchasing agent and keep the books, money and accounts, and handle the expense funds. He could even, on a pinch, fill a man's place in field, for a few days, until another man could be obtained. The right kind of a doctor would not be a superfluity by any means, even when all the men were well. He would perform many of the duties which ordinarily fall to the camp draftsman, and could divide the work with the latter. He could assist him also by calling off notes for platting maps and profiles.

The laborers' camps should also have the services of a physician. He could perhaps attend to several camps, going horseback and making regular rounds.

Some resort outside of the malarious regions should be provided where patients can be sent to recover their health and strength. Those who do not recover, or who frequently relapse on returning to work, should be sent home to their own country.

Those who would wish to escape attacks of malarial fevers, must, besides avoiding the bites of mosquitos, live a decent and wholesome life. Avoid exposure to bad weather, extreme fatigue, loss of sleep, late hours, indiscretions in eating and drinking, dissipation and licentiousness. Any extraordinary drain upon the vitality of the individual may bring on an attack of ague, which might otherwise have been staved off. Any observant person who has had "the chills," can tell by his own sensations two days beforehand when an attack is coming. He feels "aguish," but does not have an attack. Two days later he may look for one. By taking a few doses of quinine in the interval he may escape the attack altogether.

GOOD DRINKING WATER.—Good drinking water is essential to health, and should be provided at any cost, but it can generally be obtained very cheaply. Spring, well or running water is best. Avoid pools, ponds and stagnant water.

The writer once had a party working in the swampy "sunk-lands" of northeastern Arkansas far from any habitations. There was no good water anywhere, but the party had what is known as a "drive well." It consisted of four 6-ft. joints of ordinary 1½-in. gas-pipe that could be screwed together with ferrules, a brass-pointed strainer, a cheap pitcher pump, and two pairs of pipe wrenches. As soon as we moved camp to a new place, we would drive a well. Starting with one joint of pipe, with the brass-pointed strainer screwed on, we would drive it into the ground with a wooden maul. Then we would screw on another joint and drive on down. We kept on adding and driving a joint at a time, until we reached water, generally at a depth of about 20 ft. Then we would screw on the pitcher pump, prime it, and pump until the water came clear. After that we would have pure cold water at any time. When we moved from that camp we would pull the well up by means of a lever and chain, and take it to the next camp and use it again.

The railway in the tropics should have an ice-plant at headquarters to furnish ice for general use, for the hospitals, and for the preservation of perishable food, but in camps too far from headquarters, the water can be cooled after the native method. Get a large unglazed earthware jar called an "olla." Set it or hang it up in a cool place, in a draft of air, in the middle of a room or hung up by a rope to the ridge pole of a tent, or under a shade tree. Fit a wooden cover on the "olla" to keep out bugs and trash. Fill it up every morning with fresh spring or pure water. Enough water will soak through the porous jar to keep the outside constantly wet, and the evaporation of the water on the outside will cool the jar and its contents. You will find the water in the jar much cooler in the evening than it was in the morning when you put it in. A long-handled dipper completes the outfit, and a cool refreshing drink, much better and healthier than ice water is always at hand. Water bottles, made of the same material, are in use for the dining table, and cool the water in the same way.

As an adjunct to the olla, near by can be kept a few glasses, a basket of lemons or limes, a bowl of sugar, a few spoons and a knife. You then have the "makings" of a glass of cool lemonade, as required, very healthy and refreshing, coming in from a hot drive. Some add a bottle of rum handy near by, to reinforce the lemonade, but it is a question whether this is beneficial. Some physicians consider alcohol in any form injurious in the tropics. Some pronounce it a rank poison. It is said that wine killed more Frenchmen on the Panama Canal than the climate.

MOSQUITO BAR.—Have the top of the mosquito bar made rectangular and just a little smaller than the size of the cot. Have the sides made quite full, gathering in at the upper edge. Use no sticks or spreaders, but put a small tape loop at each upper corner. An extra loop midway will help take out the sag. Into these loops tie long strings. Tie the strings to any convenient place, a nail, a hook, a branch of a tree, any way so as to make the bar hang squarely over the bed. If in a tent put safety pins in the canvas, and tie to them. The sides of the bar should be from 4 to 6 ft. high and should hang inside the frame of the bed and should be tucked in under the edge of the blankets or mattress all around. Do not let the bar hang outside of the frame of the bed. The mosquitos will come up from below. Do not have any slit on the side, to gap open, when you are asleep, and let the enemy in. If there is a slit there, sew it up, if you want any peace. When you go to bed, raise the lower edge, slip in quickly, like a boy going in under the circus tent, and tuck the bar in again after you. If there is any opening left anywhere the mosquitos will find it. The strings you tie the bar up with should not be too strong, so that they will break if any accidental strain is put upon them. It is better to break the cords than tear a rent in your bar. The cord is easily mended but the rent is not. The best and quickest way to mend a hole in your bar is to pucker up the material around the hole and wind a string round it, and tie in a knot. It is not very pretty but it is effectual.

The mosquito bar will not only keep out mosquitos, but flies and all sorts of flying bugs and crawling creatures, and even the blood-sucking bats that are plentiful in some places, to say nothing of the tarantulas, centipedes and scorpions (alacrans) that sometimes become familiar and want to get in bed with you.

COMMISSARY DEPARTMENT. — Buy an abundance of good, wholesome supplies and keep them "a coming." Do not allow yourself to run out or near out. Always know when and where you can get more. Keep stock of supplies as near at hand to the work as possible, and don't let them run down. A well-fed man will do more work and be cheaper than a dozen starved and discontented ones.

Buy in the country anything and everything that is good to eat. Almost anything is better than canned goods. The latter are very dear in tropical countries and should only be used when other supplies fail. Things to eat are generally cheap in tropical countries, but do not let the price hold you back. Nothing is too costly, if it will promote the health, comfort and contentment of the men. They have privations enough, without denying them any luxury obtainable.

In a country where game and fish are plentiful, it will pay the company to hire a native hunter, or two of them if necessary, for each locating party or camp, to hunt and fish for the camp. They will furnish fresh meat, and the saving in the regular supplies will more than counterbalance the slight expense.

When near a town with a market, living expenses are generally cheaper than in the United States. The writer had a Resident Engineer's camp in the State of Oaxaca, Mexico, three miles from a good sized town, with a good market. There were about eight Americans and Englishmen in the camp. We set a fine table, including fresh beef, turkeys, chickens, all kinds of vegetables and fruits, and the cost of food alone was only $22 per man per month, Mexican money, worth then about 70 cts. gold.

The native laborers generally feed themselves, obtaining their supplies from any source nearby. The contractors should keep on hand a supply of the kind of food to which they are accustomed, selling it to them on account or for cash. They prefer their own kind of food and cooking. The writer has seen them turn up their noses at a good square American meal, and say there was nothing on the table they liked, chiefly because it was not cooked their way. In locating parties the native helpers also feed themselves, buying their food wherever they can get it. In a barren and uninhabited country it is hard to keep help on that account unless you take pains to bring from a distance such food as they require.

READY CASH.—Always have money on hand to pay salaries and native wages when due. Pay-day is generally once a week, Saturday afternoon. An American whose salary is overdue can generally be satisfied with any reasonable explanation, but not so with the natives. They are suspicious and will quit work if not paid at the regular time. A subcontractor who succeeds in establishing a reputation for prompt payment and kind treatment can generally get all the men he wants, while the "sub" who has done something to displease them, knocked a man down for some small offense, kicked a man out of his office for complaining of some trifling shortage in his wages, or charged an extortionate price for some article sold, or failed, by a few days,

in paying his men, will be deserted and will be scouring the earth to find men. The natives have no daily papers to inform them of what is happening along the line, but news travels from mouth to mouth with remarkable rapidity.

Personal Affairs.

There are many items in the personal conduct and life of the men which affect strongly the success of an expedition. These are worth while recording.

In leaving the United States to work in Latin America, remember that courtesy is universal in those countries. The poorest peon is often a Chesterfield in his manners and speech. Do not allow any one to be more polite than you are. Americans have a reputation there of being brusque and ill-mannered. Try to overcome that impression. Do not show any American self-conceit, or boasting, and never lose your temper even under provocation. Be cool-headed, thoughtful of the impression your words are making, never impulsive unless it be in an act of kindness. Take things cool, and never walk fast. It is bad practice in a hot sun and may cause people to ask, "Who is sick," or "Where is the fire." Do not work in the middle of the day, take a "siesta."

INDIVIDUAL EQUIPMENT.—Make your baggage and personal effects as light as possible. If you take a trunk, let it be a small steamer-trunk, or if that is not enough take two of them in preference to one big trunk. The two will balance nicely on the back of a mule, which is almost the only mode of conveyance in that region. The engineer going into the field will have to leave his trunk at headquarters until he returns, and be satisfied with a grip or bag. In outfitting in the United States, remember you can buy clothes and underwear cheaper in the southern countries than at home. However, if you are a large person, buy in the United States, as the goods kept in the stores down there are for small-sized people, and you will find it difficult to get anything large enough to fit you. Buy your shoes in the United States, several pairs. Wear each pair one day, to dirty the soles, so they will pass the custom house, as personal effects, instead of merchandise. Pull all the store tags off your clothing, and muss them up a little, throwing the boxes away. If you put the things in your trunk just as you buy them in the United States, they may suspect you of smuggling, and make you pay duty. Personal effects enter free, but merchandise does not.

You will have to carry your bed and blankets with you in the southern countries. Bed clothing is not supplied in the hotels except in the largest cities. In the country places you will have to supply your own bed and make it down wherever you can, generally on the floor, and often a dirt floor at that.

A suitable equipment will contain:

A woolen double blanket. Two or more of them if you go into the high altitudes.

A "Gold Medal" folding cot.

A rubber air pillow.

A mosquito bar.

A hammock will be found useful in some places.

A rubber blanket to keep the bed dry when it rains.

A canvas cover, six by twelve feet, or larger, to roll your bedding in, when moving camp. It can be used at night as additional cover, or spread out to keep your blankets clean.

A stout rope about 25 ft. long to tie up the bundle. When not in use it can be stretched in the tent to hang up your clothes.

All these can be rolled up in one bundle. Put the rubber blanket inside the canvas, as it is easily torn on mule-back. For the rubber blanket, a rubber poncho may be substituted, to be used when riding horseback in the rain, and to cover the bed at night. The poncho is also a substitute for a rubber coat in rainy weather.

A sailor's bag such as is used by the "jackies" in the navy, or a canvas bag made after the fashion of a mail sack, with strap and padlock, is a good thing to carry your clothes in, better than a grip. The first trip on mule-back will ruin the grip, but a bag will last a campaign.

Leave your fine clothes and starched shirts at headquarters when you go out in the country. You will get no washing done except by some peon woman, and you will have to furnish the soap. She will take your "ropa" to the side of a brook or pool and wash it in cold water. She will pound the clothes with a club on a flat rock, a log or a stump. She will bring your shirts back to you full of holes, and all the buttons off. If you don't like it, wash them yourself. Washboards, starch and flatirons are unknown in that country except in the large cities.

Engineers, and others also, should keep a private supply of quinine. There is no effectual substitute for it, when you need it.

Tobacco can generally be bought there cheaper and better than here. Always lay in a good supply when you expect to be gone a long time in a place where you can get none. Men sometimes suffer terribly for lack of it, even to the extent of being rendered unfit for work.

A good revolver should be carried. You will not need it, as much as you do in the United States, but it is the custom in those countries for every gentleman to carry one, principally as an ornament, but very seldom used. The sight of it also commands the respect of drunken and unruly natives, who might insult you if they found out you did not carry a gun. Carry it outside where every one can see it.

GETTING LOST.—One thing which should be made a matter of caution to engineers and others who find themselves isolated in a vast uninhabited wilderness, is not to stray off by yourself and get lost, causing great anxiety and trouble, not only to yourself but to your companions, even if you escape unhurt. Some conceited men think they cannot get lost, but their turn will come. Every man in the party should constantly carry a small pocket compass, as a precaution, in case of accidental separation from the rest. There is little trouble in following back a line which you have surveyed, if you are on the line, but the trouble is to find the line after you have lost it. You must know in what direction to find it. A man should no more think of going into a tropical forest without a compass than he would go to sea without one. Without it you have no means of getting your direction. In a few moments you are turned round. If the sun is seen at all, it is directly overhead, and you can tell nothing by it. There is no moss on the trees to guide you. Distant elevations or mountains, if there are any, cannot be seen on account of the density of the forest. If you discover that you are lost, it is safest to stay where you are and await the coming of your friends to rescue you. Shout and fire off your gun at intervals. Distress signals should be arranged beforehand, and every one within hearing should answer and at once hasten to the rescue. You should not rush blindly through the forest, probably traveling in the wrong direction or in a circle. Save your strength and prepare to spend the night if necessary. Your friends will have a shorter distance to trace you if you stay where you are. In going to work don't let one man rush off ahead of the rest. There is no use in it. He can generally do nothing until they are all there. Stay together.

On the grand llanos of South America, when the mountains are too far away to be seen, you will need a compass as much as in the forest. If it is morning or evening you can tell east and west by the rising and setting sun, but at midday you can tell nothing by the sun. It is almost directly overhead. At noon one can often stand in the shadow of his hat. At twilight it is difficult to get direction until the stars appear.

"CHIGGERS."—Our old and familiar friend, the "chigger," or as technically called the "chigoe," will be the cause of much trouble. They are in all the western and southern states, and in the seacoast country of Mexico, Colombia and Ecuador, and no doubt they exist in the Amazon region. The writer has suffered more bodily discomfort from these minute, almost microscopic little red devils, than from all other causes combined. He has tried every remedy, both for prevention and cure, that was ever suggested, but without relief. Now comes Dr. Wiley, who says that a solution of the hyposulphite of soda is a sure cure. It will be worth while to try it.

PROTECTION AGAINST SAVAGES.—Having had no personal experience in running lines through a country infested by hostile savages, the writer would suggest in an open country the method of the Southern Pacific parties in Arizona and New Mexico. The United States Government furnished a sufficient number of cavalry. During the day, when the parties were at work, pickets were established on all sides at a distance of half a mile or more, wherever a hill or elevation afforded a good view of the surrounding country. These pickets moved along, keeping abreast of the party as they progressed in their work. The members of the surveying parties were also armed. The cavalry escorted the party to and from their work. The camp was also guarded by day, and at night pickets were kept out, as in time of war, to prevent a surprise.

As to what could be done in a forest country against lurking savages armed with noiseless and poisoned arrows, the people and authorities in those countries, who know the nature and habits of the hostiles, could probably be depended upon to suggest some means of protection. The "reconcentrado" method used by the Spaniards in Cuba against guerrilla warfare might prove effectual. The hostile Indians, with their women and children, could be gathered into a reservation and put under guard. It is always cheaper to feed a hostile Indian than to fight him on his own territory. The United States has proved this policy. The Seminoles of Florida were never subdued until they were moved to the Indian Territory and put on a reservation.

Methods and Equipment.

As was noted in the first part of the article, the one important factor in tropical engineering work is the man, but the equipment of the party and the methods pursued are of next importance.

METHODS OF WORKING.—The ordinary means used in Spanish countries in grading for railways is hand labor. The pick, shovel and basket are the tools. Wheel and drag scrapers are little used for lack of motive power. The mules are small and not trained to work in harness. Imported American mules are very expensive and the death-rate is high, on account of the change of climate and food. It will be necessary for the contractor to train the native mules to harness, and use small-sized scrapers.

In rock cuts the usual methods are followed. The material is carried to the dump in carts, drawn by native mules, which have to be "broken in" to work in a cart.

Native hand labor is best worked by task or "tarea" as it is called. The ground in the borrow pit (or cut) is marked off in squares of suitable size, and each man is assigned to a square, which he is required to take out to a certain depth. The tarea is varied in size, according to the hardness of the material, and will constitute a day's work. Some men will hurry and get done by 3 p. m., while others will work until sunset to finish their task. The task-master or timekeeper will pass around at sunset and receive each man's work if completed. If the work is not satisfactory, he must complete it before it is finally received. The size of the tareas are varied according to the hardness of the material. Sometimes the men will strike for smaller tareas, and they may have to be reduced in size to induce them to work.

For masonry, the contractor will find pretty good masons and stonecutters in all the large cities. He will also find good blacksmiths, carpenters, tailors, shoemakers, saddlers and tinsmiths. They are very slow, but their wages are correspondingly small. Pile drivers, bridge carpenters, grading and track foremen, train hands, steam engineers, and skilled railroad men of all kinds, will have to be imported, at least in sufficient numbers to train the natives in their various duties.

It is good policy to employ as many natives as you can, in positions high and low, provided they are able to fill the positions. In some concessions, the government has required that a certain percentage of the employees shall be natives of the country.

THE ORGANIZATION OF ENGINEERING PARTIES.—The only men whom it is really necessary to import for the engineering work in the tropics are those who fill the higher positions, the chief of party, the transitman, the leveler, the topographer and the draftsman. There is always a sufficient supply of natives to fill the other positions. Free schools are common everywhere, and even among the peons are many men of intelligence, who can read and write, and will quickly learn to become rodmen, chainmen and flagmen. The axmen should be natives of the country, but even they should know how to read and write, and I have been accustomed to give preference to men who can read and write whenever they can be obtained.

However, when a party is working in a remote and isolated region, there should also be in the party several extra skilled men, who have had some field experience and technical education, and who have knowledge of the use of instruments, or who could be readily taught to use them. These men can be hired as rodmen or chainmen and be on hand to fill the higher positions, in case of sickness, or any other disability of the regular instrument men. This plan will keep the work going, which is an important matter, as the expense of a locating party is about $50 per day to the company.

TRANSPORTATION DEPARTMENT. — Organize an adequate and efficient transportation service, whether it be on the sea, on rivers or on land. The company should be supplied a sufficient number, if necessary, of ocean steamers, tugboats, barges, river steamers, steam launches, boats, canoes and pack-mules to keep supplies and men always in motion. Many of these can sometimes be hired, but the company should own enough of them to be independent of extortion, strikes and delays of all kinds. No corps of engineers or camp of laborers should ever be able to say that they could not move camp, or had to stop work, because of a lack of transportation, men or supplies.

In building a railway it is a good plan, even before the clearing is done, to put up a telegraph or telephone line, reaching from headquarters to every contractor's and engineer's camp. It is a great saver of time, trouble and expense, and brings all parts of the work in touch with headquarters.

A "line rider" or two to carry mail and small packages, and to take a force account, is needed. He should make a trip daily and call at every contractor's and engineer's camp, following always the railway line if possible, instead of the public highway. A man who will furnish his own horse can generally be hired for this work at about a dollar a day. He will get his horse and himself fed at the camps whenever he happens to be at the meal time.

EQUIPMENT.—Machinery, where it can be brought in and used, will be a fine thing in tropical countries. It will not displace any manual labor, as the labor is scarce and inefficient at best. It will save time. It stands the heat, and never tires. With a few men, working in relays, a steam shovel accomplishes the work of thousands. The work at Panama is an example.

In a difficult, inaccessible country, a locating party should have on hand two transits, two levels, and three or four chains or tapes. Accidents are bound to happen, and every precaution should be taken that the work shall not come to a standstill, even for a few days. The extra instruments are also very handy for putting out a small party to run extra lines, land lines, drainage areas, check levels, to cross section some work to put a subcontractor at work. All these things can be done by the few extra men, without stopping the work of the main party.

Train all the men to work in any position, even to take an ax if necessary. Work them around in different positions. You will thus learn what each man can do, and be prepared for all emergencies.

In those countries it is customary to furnish a native instrument-bearer to both transitman and leveler. These helpers can carry the instrument to and from camp, and during the day from point to point. The company furnishes each white man with a saddle horse to ride. One or more men take care of the horses while the work is going on. Native labor is so cheap that it does not pay to economize in the number of men. The natives walk to and from their work. A white man cannot stand that in the tropics. It would unfit him for work, and waste his strength. There would be no economy in it.

A water carrier is also necessary to supply drinking water to the men in the field. It is cheaper to do that than to allow a man to leave the party every time he gets thirsty, even when the water is not far off. A light noon-time lunch is brought from camp, but the less a man eats in the field, the better he will feel. A pot of hot coffee made in the field and dispensed in tin cups is very refreshing. A short siesta in the shade after the lunch is beneficial. Work should be suspended during the hottest part of the day. Work should be started at sunrise, and should be stopped in time to get every one back to camp at half past six, unless the roads are good and well known, when a little longer time can be taken. Twilight in the tropics is very short. The sun sets at six the year round, and in half an hour it is quite dark. In the rainy season the forenoon is generally clear, the storm coming on at noon. The rain lasts from a half hour to several hours. The sun generally sets clear.

METRIC SYSTEM.—This system is in general use in the Latin-American republics, and it is not difficult to adapt American methods to it. The chain in use is 20 meters long (66 ft.). The stations are made 20 meters long, and there are several ways of numbering the stakes, each of which has its advantages. A 2° curve is one which consumes 2° of central angle in every 20 meters (66 ft.) of distance. Consequently a 2° metric curve is nearly equivalent in sharpness to a 3° curve with us, using the foot system, with stations 100 ft. long. The same relation applies to all degrees of curvature. A metric 4° curve is equal to our 6°. Conversely our 1° curve is the same as a 40' metric curve. In using the tables, take out the tabular number for the central angle as usual, divide by the degree of the metric curve, and then by 5 and the result is in meters.

In leveling the change is so simple as to require no description. In reading rods on turning points in railway work, there is no advantage in reading to less than centimeters. About as good results are obtained as you would get by reading as fine as to millimeters. In marking cuts and fills on stakes, mark to centimeters, as the decimeter is too coarse to grade by. Besides in figuring quantities simply add the two areas, strike out the decimal point and you have the result in cubic meters, that is for a 20-meter station. There is no dividing by 2 and 27 as in figuring cubic yards.

General Instructions.

CONCESSIONS.—In doing work in the tropics, it is well to keep in mind the fact that it will take at least twice as long and cost twice as much as the same work would if located in the United States.

In getting a concession do not accept too short a time-limit upon your work either in starting or completing. Get as liberal an allowance of time as the government will consent to. Then begin the work as soon as possible and push it to completion as hard as you can. Doing your best, you may consume all the time allowed, and have to ask for an extension. This will generally be granted if the contractor has already shown an earnest disposition to push the work.

Get a liberal concession as to grades and curvature, as it may sometimes be necessary to use steeper grades and sharper curves than you ultimately intend shall prevail. In a sparsely settled country, where labor is scarce, it is good policy to put in temporary and cheap construction, whenever it will save either time or money. Getting the road into operation, and earning money, should be the first consideration. Remember, also, that in the tropics, permanent work and improvements can be made for less money and in a shorter time after the track is laid than before. Therefore sacrifice everything to the advancement of the end of the track, and the putting of the road in operation. Then if the traffic should not come up to the expectations of the projectors, improvement work can be deferred until the earnings of the road are sufficient to justify the expenditure. If this policy is not pursued, the road will perhaps go into the hands of a receiver as soon as it is opened for traffic.

THE CHURCH.—The Roman Catholic religion is almost the only one in those countries, and the clergy have a controlling influence over the people, and their ill-will is a thing to be carefully avoided. Conform, outwardly at least, to the prevailing customs of the country. Doff your hat when you pass an open church door, or when a religious procession is passing in the street. It won't hurt you, and it may prevent a shower of rocks flying about your ears, if you don't.

The local priest is generally an educated, companionable fellow, really more liberal than his parishoners. A call on the priest, an occasional invitation to dinner, a social glass, a delicate offer of a small contribution to the church, will generally suffice to put you in good standing. You need not attend the church if you don't care to. The word of the priest is law to the poor peons, and he can prevent them from working for you, or from furnishing you with supplies, or rendering any service whatever. Get on the good side of the padre by all means.

If there are a large number of natives collected in one locality on the work, and no priest near by, get the bishop to send one, support him and treat him well. It will pay in the increased peace and contentment of the laborers.

THE LOCAL AUTHORITIES.—You are also to stand well with the local authorities, the Alcalde, the Governor and the President himself. Where large bodies of men are collected, there are always a number of bad, unruly men to make trouble, especially on pay-day. The authorities will always cheerfully furnish a squad of soldiers and an officer to keep order. The contractors are thereby saved the trouble of taking the law into their own hands. The pick-handle and revolver play is bad policy. The contractor thereby comes in conflict with the authorities, is arrested, fined and perhaps imprisoned.

The officer and the priest are always well-educated, courteous gentlemen, and can be invited to the hospitality of headquarters and to mix socially with the employees there.

Do not undertake to be a missionary and a railroad builder at the same time. Let your own conduct be irreproachable, but don't interfere with the religion, morals, customs or habits of the natives or the political affairs of the country. "Mind your own business" is a good rule there. Don't affect any "holier than thou" attitude. Remember that you are doing a good work and that the locomotive is the greatest civilizer of the world, and will silently dispel more narrow-mindedness, bigotry and superstition than all the missionaries you could send into a country. It is also a sure cure for revolutions. Witness Mexico, before and after taking.

Successful railroad contractors in the United States will not necessarily succeed in tropical countries. It requires something besides energy, push and bull-headedness to succeed there. Brainwork and forethought will accomplish more than main strength and awkwardness.

Don't squander all your capital on influential men, grafters and men with an ax to grind. Don't charter any old rotten ships to please a friend. Be sure the owners don't want to get rid of them, to collect the insurance. Don't send river steamers, tugboats or other small craft not intended for sea-service to sea by themselves. They should be accompanied by a sea-going steamer, and taken in tow, with only men enough on them to manage and steer them. They should travel along the shore, only in good weather, and should go into a harbor during stormy weather. It would be better to send such boats to foreign countries in sections when it can be done.

An Additive Method of Computing Run-Off to Sewers.*

By CARL H. NORDELL.†

Probably the first attempt to formulate a method of storm-water sewer design was made in 1849 by an English engineer, John Rowe, who compiled a set of tables showing the acreage supposed to be drained by various sizes of sewers, laid to different grades. It was, naturally, extremely crude, no allowance being made for any of the varying factors of different drainage areas, such as rainfall, imperviousness, slope or manner of collection, all of which have a marked influence upon the necessary sizes of sewers.

This crudeness was, to a certain extent, remedied by formulas so constructed as to take some of these variables into consideration. The first to come into general use was the Bürkli-Ziegler,

$$Q = ACR^4\sqrt{\frac{S}{A}}$$

in which A is the acreage, R the maximum rate of rainfall in inches per hour, C a coefficient of imperviousness and S the average slope of the drainage area in feet per thousand.

This formula has usually been found to give too small results and it was probably this that induced McMath to propose his modification of the expression from data obtained by gaging the flow of sewers in St. Louis. The formulas devised by Hering and Parmley give still greater results than McMath's. For the purpose of comparison they may all be written in the same form:

Bürkli-Ziegler, $Q = A^{\cdot 75}\ S^{\cdot 25}\ C\ R$

McMath, $Q = A^{\cdot 80}\ S^{\cdot 20}$ C R

Parmley, $Q = A^{\cdot 833}\ S^{\cdot 35}$ C R

Hering, $Q = A^{\cdot 85}\ S^{\cdot 27}$ C R

It will be seen that the form has been kept exactly the same but the exponents of A and S changed so as to give greater results. Then, too, the tendency has been to increase R, McMath using R = 2.75 while Parmley took $R = 4$, a considerable increase.

These formulas are entirely empirical and give correct results only for areas identical with those from which

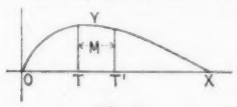


Fig. 1.

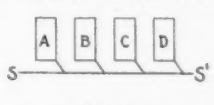


Fig. 2.

they were derived, because of some very important factors in determining run-off—the shape of the area, the manner of collection and the time of concentration—are left out of consideration entirely. Then, too, the value of S affects the run-off in an entirely different manner in different portions of an area. For instance, a large value of S in the upper portion of an area and a small value of S in the lower portion tends to a large run-off, since the maximum rate of rainfall from the upper end reaches the lower end of the area before the maximum rate in that portion has been discharged. Obviously, if the slopes are reversed the opposite condition holds, even though the average slope of the whole territory remains the same.

The "Rational Method" of run-off determination, as developed by Emil Kuichling, overcomes some of these inaccuracies. Here the time of concentration is employed in determining the run-off. Q is taken equal to $A\ C\ R$, in which A is the acreage, C the coefficient of imperviousness and R the average rainfall for T minutes, T being the time taken by the water to flow from the furthermost point of the area to the point under consideration. This method does not, however, adapt itself exactly for varying slopes and manners of collection, for it will readily be seen that we may have any number of areas whose time of concentration from the furthermost point is the same and yet vary widely in shape and manner of collection.

When Parmley designed the Walworth St. sewer in Cleveland, which drained a triangular area, the line of the sewer being approximately the median of the triangle, he found that the time of reaching any point in the main trunk was about the same for the limits of the area. Instead of applying a formula directly in order to determine the run-off to be carried by the main sewer, the run-offs for the contributory trunks were determined by his formula and the discharge of the main trunk was taken as their sum. This method was undoubtedly correct for that particular drainage district, but could not, of course, be used for any drainage district in which these peculiar conditions did not obtain. None of these formulas or methods can therefore be relied upon to give correct results for all areas and considerable judgment must be used in applying them. Since using an empirical formula with judgment involves much guess work, it would seem better to outline a method correct in theory and employ judgment in fitting practice to theory.

If, therefore, we begin an investigation of run-off from a surface such as an inclined plane, where the most simple conditions possible prevail, we will probably be enabled to build up a method of determining the run-off from any area made up of a number of such surfaces.

The rainfall is, of course, never constant for any considerable time and must therefore be at a maximum for some time during the continuation of the storm. This will here be called the "maximum rate" and the greatest flow of storm water past a given point, "maximum flow." Suppose the plane to be included from the upper edge P' to the lower edge P, the length of time taken by the water to flow from P' to P will be called the time length of the area. The problem is to find the amount and time of occurrence of the maximum flow at P.

In Fig. 1 let the line $O\ Y\ X$ represent the rainfall curve of a storm, of which the abscissas are the time in minutes reckoned from the beginning of the storm and the ordinates the actual rates of rainfall in inches per hour. Then, if the time length of the plane be M, or the distance between the ordinates T and T', the maximum flow will occur at P when the area of the curve between the ordinates becomes greatest as they are moved over the curve M minutes apart and will be equal to the product of the area of the plane and the average rate of rainfall between T and T'. This average rate is, of course, equal to the area of the curve between the ordinates, divided by M.

In order that these results should hold exactly it would be necessary that M should not change for different values of the maximum flow and that the velocity over the plane should be uniform. This can never be exactly true, but since it is proposed to use these results for small areas only, the error is more apparent than real and if correction were made the ultimate results would be affected only to a very small extent.

If the maximum flow is collected into a channel at the edge of the plane and conveyed to a corner, C, the time and occurrence of the maximum flow at C can be determined in the same manner, if the distance between the ordinates be taken as $M + N$, N being the time taken by the water to flow the length of the channel.

Let us now consider the conditions obtaining in a sewer or channel when several of these simple areas are drained into it. In Fig 2, let A, B, C and D be such simple areas draining into the sewer $S\ S$; flowing from S to S'.

If the maximum flow from A occur at the time, T, the maximum flow at B has run off by the time the flood wave from A reaches B, that is T'. This area is then discharging at a rate due to T'; that is, the flow added at B is due to an average rainfall between the time-length ordinates of B on the rainfall curve with the far ordinates taken as T', multiplied by the area of B. Then this combined flood wave passes to C, when another quantity of water is added equal to the area C multiplied by the average rainfall between its time-length ordinates with the furthermost ordinate taken at T'', etc. It is possible that the maximum flow at any point will occur before the maximum flow from the furthermost area arrives, if the near areas are large and the further areas small. In this case the maximum flow would be equal to the maximum flow from the near areas plus a pre-maximum flow from the further areas. Suppose this were the case at D, then the mixmum flow would occur when T''' was taken, so that the average rate between its time-length ordinates was greatest, and the maximum flow would be equal to the sum of the maximum flow from D plus the pre-maximum flows from C, B and A obtained by multiplying their areas by the average rate between their time-length ordinates, the further ordinates being taken, respectively, at T'', T'' and T^{s}, reckoned from T'''. If the areas are unequal in time-length and vary in size the time and amount of maximum flow can only be determined by trial.

We can, therefore, determine very accurately the time of occurrence and amount of maximum flow from any complex area made up of such simple areas. In a drainage system these simple areas are in reality very small, such as sidewalks, courtyards, roofs, etc., but as hair-splitting accuracy is not needed we may consider an ordinary city block on the area draining into a catch basin as being a simple area.

The primary point in determining run-off is in choosing a rainfall curve for which the sewers shall be designed. Fortunately we have at present fairly good data for this, giving the average rates of rainfall for each five minutes of a storm. Formerly it was considered sufficiently accurate to take the average rainfall for an hour as a basis in sewer work, but it has been learned by costly experience that such data are almost worse than useless.

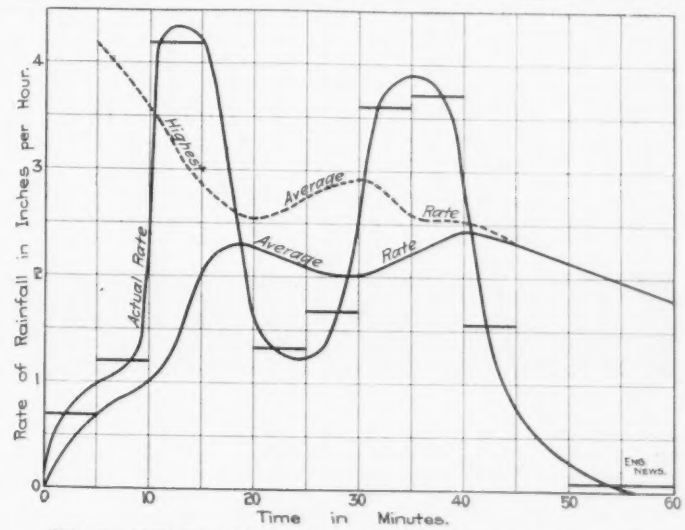


FIG. 3. CURVES FOR EXCESSIVE RAINFALL AT NEW YORK CITY, AUG. 1, 1904.

(See Table I. for figures of this and four other excessive rainfalls at New York.)

The storm curves are plotted from the rain gage records of the Department of Water Supply, Gas and Electricity in Brooklyn and the U. S. Weather Bureau's gage in Manhattan, New York City. The records of excessive storms were compiled by the Bureau of Sewers, Borough of Brooklyn, by whose courtesy they were furnished to me, and show the average rates of rainfall for each five minutes after the beginning of the excessive rate. Only five of the most exceptional have been plotted in the form shown here. [We reproduce only one of the diagrams (Fig. 3), but give in Table I. the leading figures for each of the five storms.—Ed.]

The curve marked "actual rate" was drawn by a "trial and error" method in such manner that the average value of the curve between the five-minute prioda corresponds to the average five-minute rainfall shown by the records. As this method allows considerable latitude in drawing in the curve it is probable that the real curve differs somewhat; but pains were taken that it should be as simple and consistent as possible.

The curve marked "average rate" is the average of the proceeding five-minute rates—the usual rainfall curve. It will be noticed that some of the storms have also a dotted line marked "highest average rate." This is due to the fact that in these storms the highest average rates occur after the storm has been in progress. For instance, in the storm of Aug. 1, 1904, (Fig. 3), the average rate for the first ten minutes was 1 in., but the average for the second ten minutes was 3.6 ins.

One striking feature of most of these excessive storms is that they occur almost invariably in the summer months, when the conditions are most favorable for a large percentage of the rainfall being absorbed by unpaved surfaces. Only two have occurred in the winter months when the ground is frozen and practically impervious. Undoubtedly a curve could be chosen large enough to absolutely preclude any danger of the sewers ever being flooded by these storms, but it is doubtful if such procedure would be wise. In the first place, the initial cost of the sewers would be very great, indeed, and in the second they would be ill adapted to serve sanitary flow if they were "combined sewers." In New York City it has, I believe, been rather general practice recently to use McMath's formula, with R taken as 3. Just how much rainfall this provides for it is difficult to say—in fact, it varies with the area. As will appear later, however, it seems to provide for a rainfall of 3

TABLE I.—FIVE EXCESSIVE RAINFALLS IN NEW YORK CITY.

	July 10, 1905.	July 12, 1899.	Sept. 12, 1906.	Aug. 1, 1904.	July 5, 1901.
Duration of excessive rate, min.	35.	80.	50.	60.	80.
Precipitation during excessive rate, ins.	2.11	2.19	1.47	1.80	1.70
Precipitation before excessive rate, ins.	0.4	0.0	0.11	0.0	0.0
Total precipitation, ins.	2.56	2.19	1.58	1.80	2.02
Total duration, min.	101.	80.	67.	60.	141.

*A paper read before the Municipal Engineers of the City of New York, Feb 24, 1909.

†Bureau of Sewers, Borough of Queens, New York City.

ins. for about eleven minutes and, of course, a lesser rainfall for longer periods. In order not to make too radical a change from present practice, the rainfall curve chosen for designing sewers in the Borough of Queens was taken for 3 ins. for ten minutes and then decreasing in a curve whose equation is $\frac{600}{(T+414)^2}$.

This is, of course, the actual storm curve and gives an average rainfall as follows: 3 ins. for 10 mins.; 2.05 ins. for 25 mins.; 0.98 in. for 60 mins. According to records of storms in Brooklyn from 1895 to 1906, inclusive, the 3-in. rate for 10 mins. has occurred 14 times; the 2.05-in. rate for 25 mins., 10 times and a 1-in. rate for 60 mins., 13 times. Six storms equalled or exceeded all three rates; seven storms equalled or exceeded the first two rates and nine storms equalled or exceeded the last two rates. It is, therefore, probable that a system so designed will be flooded about every two years, when all the laterals are built and discharge from a territory sufficiently developed to give the assumed percentage of run-off.

In order to use the "additive method" it is necessary to know approximately the time-length of the blocks, as they are to be considered simple areas. Unfortunately there are absolutely no data upon this very important point and it must be worked out from certain assumptions. Suppose a block 800 ft. long and 200 ft. wide to be sloped so that the drainage is all to one corner from the corner diagonally opposite. The total length of run-off for the flow from the streets is then 1,000 ft. If the velocity in the gutter is 1.5 ft. per sec., the time of running for the 1,000 ft. in the gutter would be about 11 mins. and if 2 mins. were allowed for the water to flow the 15 or 20 ft. from the center of the street to the gutter the total time-length would be 13 mins. for the flow from the street area. If the velocity in the sewer draining the roofs and yards is taken at 3.5 ft. per sec., and the time of running off the roofs and yards is taken as 2.75 mins., the time-length of the roofs and yard area becomes 7.5 mins. As these data are based on assumptions that do not always hold true it was thought better to use them rather advisedly, taking 10 mins. as the time-length for both street and roof water combined of the average block 600 to 800 ft. long with grades ranging from 5 to 20 ft. per 1,000 and 5 mins. as the time-length of very short blocks or long blocks where the grades were over 20 ft. per 1,000. When the blocks were very much longer or had a greater proportion of natural surface, this time-length was increased to 15 or even 20 mins. Probably the assumption of 10 mins. to the average block is too large and the real time is nearer 7 or 8 mins., which means more rapid concentration and consequently greater run-off; but it was thought best to be somewhat conservative in this respect until more data are available.

One of the difficulties in using any method, involving the time of concentration, has heretofore been the labor involved in finding the time of running in the sewers. The velocity had to be obtained from tables which involved a product of several factors and then the time in minutes was found by dividing the length of a sewer by the velocity in feet per second and reducing to minutes.

In order to overcome this difficulty the author designed a slide rule (Fig. 4) so arranged that if the length, drop and size of a sewer were known, one setting would give the time required to flow the given length. At the same time the rule has been so designed as to avoid the necessity of reducing to a rate per cent. in order to find the capacity of a sewer. The rule is based on Kutter's formula and correct positions on the scale worked out for $N = .013$ and .015 for brick or concrete sewers and $N = .013$ and .011 for pipe sewers.

The use of the rule is as follows: Suppose at a certain point a quantity of 100 cu. ft. per sec. is to be discharged through a sewer 700 ft. long, whose coefficient of friction is .015. If 700 on the left-hand L scale (Fig. 4) is set under the required quantity, 100, on the cu. ft. per sec. scale the different drops required by various sizes of sewers may be read off on the left-hand H scale over the divisions corresponding to the sizes on the line $N = .015$. If the coefficient of friction were assumed as $N = .013$, the rule would be set as before, but the required drop would be read on the left-hand H scale over the division on the line $N = .013$. It will be seen by the form of the rule that any coefficient may be interpolated by drawing lines connecting the corresponding divisions on $N = .013$ and $N = .015$ and also a line for N proportioned in by $N = .013$ and $N = .015$. By using the runner to project the intersections to the H scale the rule is read as before. Suppose the sewer to be established and the time of running wanted. The method of procedure is as follows:

Find the drop of the sewer on the right-hand H scale and set it over the division corresponding to the size on the line representing the assumed coefficient of friction. The time in minutes may then be read off on the T scale over the division corresponding to the length on the right-hand L scale. With the same setting the velocity in ft. per sec. may be read off by looking over the length on the left-hand L scale and dividing the reading by 10. The scales are adjusted for the sewer running .8 full; a point where the velocity is practically the greatest and the discharge .98% of the discharge running full, thus providing for a maximum rapidity of collection with a margin of carrying capacity. A scale is provided for converting the discharge for other depths of flow on the left-hand side and a scale for converting the time and velocity on the right-hand side of the rule. The reverse side of the rule is graduated into ordinary logarithmic divisions, so that it may also be used for ordinary computations. The rule is manufactured by the Keuffel-Esser Co., of Hoboken. It is 20 ins. long, engine divided, the graduations being in black upon a white celluloid face. By its use the labor involved in finding the time of concentration is so much lessened that to determine the run-off by the additive method requires very little more time than if a run-off formula were used. In order to further expedite the determination of run-off I have prepared a diagram which gives at any time the average rainfall on simple areas of known time-length.

In Fig. 5 the inner curve represents the actual rainfall, the outer curve the average rainfall. The intermediate curves show the average rainfall on areas of the time-lengths indicated on them. These were plotted from equations representing the average value of the rainfall rate between two ordinates moved over the actual rainfall curve, separated by a space equal to the time-length of the area. Consequently the discharge of any simple area of known time-length may be found at any given time by multiplying its area by the value of the ordinate of its curve at the given time. The curves were plotted for 5, 10, 11, 12, 13, 14 and 15 mins.; then for every 2 mins. to 25 mins. and then every 2.5 mins. to 35 mins.

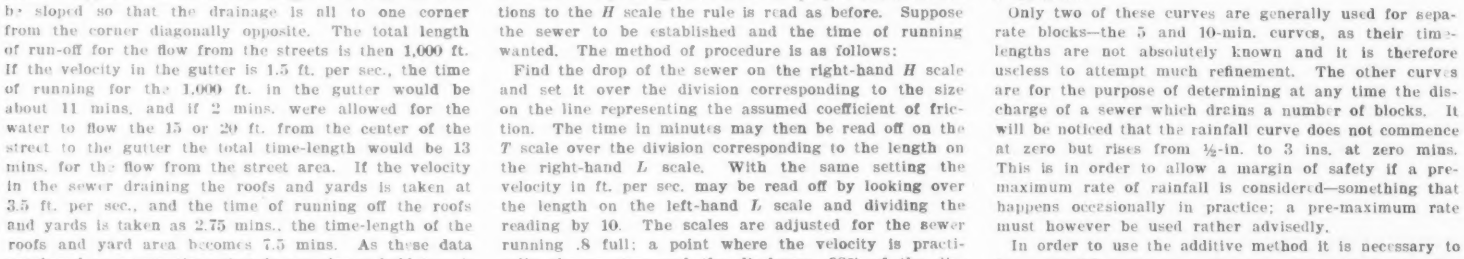


FIG. 4. A NEW SLIDE RULE FOR COMPUTING RUN-OFF TO SEWERS.

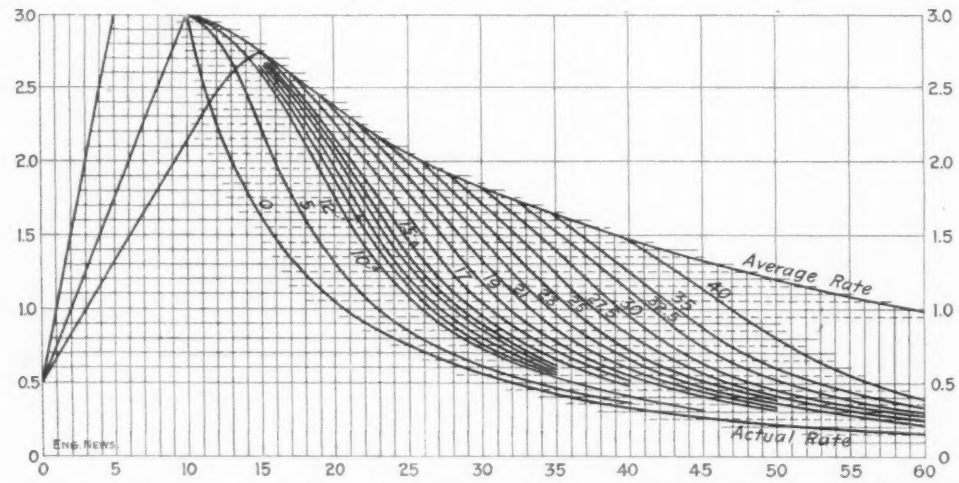


FIG. 5. DIAGRAM FOR DETERMINING AVERAGE RAINFALL ON SIMPLE AREAS OF KNOWN TIME LENGTH.

Only two of these curves are generally used for separate blocks—the 5 and 10-min. curves, as their time-lengths are not absolutely known and it is therefore useless to attempt much refinement. The other curves are for the purpose of determining at any time the discharge of a sewer which drains a number of blocks. It will be noticed that the rainfall curve does not commence at zero but rises from ½-in. to 3 ins. at zero mins. This is in order to allow a margin of safety if a pre-maximum rate of rainfall is considered—something that happens occasionally in practice; a pre-maximum rate must however be used rather advisedly.

In order to use the additive method it is necessary to keep careful rates at each sewer determined, showing the acreage drained at each street intersection, the average imperviousness, the time of concentration, etc. The form of notes shown by Table II. is the one adopted in the Borough of Queens and has been found to answer its purpose very well.

In the column headed "A" is shown the block acreage, including street and roof area, whose drainage is admitted at the point under consideration. I represents the coefficient of imperviousness, $T\,L$, the time-length of the block, T the time at which the quantity discharged is to be found, Q the quantity discharged at the time T. The "total A" is the sum of all the separate acreages, the "total $A\,I$" the sum of the products of each acreage by its imperviousness, "total Q" the total maximum quantity to be carried, which, of course, occurs at the time T. The last three columns require some explanation: when the sewer discharges into another one, the time of occurrence and amount of maximum flow for the two sewers combined must be determined. The time of occurrence will be almost invariably the time of arrival at the junction of the larger maximum quantity and will be equal to the larger maximum flow plus a post-maximum or pre-maximum flow from the other sewer. In the table the maximum flow in the Tenth Ave. sewer is smaller than the maximum flow in the Twelfth St. and arrives at the junction 11 mins. before the maximum flow from the larger sewer. It is clear, then, that the combined maximum occurs at the time when $T = 35$; therefore the quantity added to the Q in the larger sewer is due to each of the areas discharging at a time 11 mins. later than the time previously considered. Of course, this quantity might be

TABLE II.—FORM OF NOTES USED IN THE ADDITI VE METHOD OF COMPUTING RUN-OFF TO SEWERS.

Location.	A.	I.	T.L.	T.	Q.	Total A.	Total A.I.	Total Q.	Equiv. A.	T_1	Q_1
Sewer in 10th Ave., from 1st St. to 12th St.											
1st Street	4	.75	10	10	9.0	....	....	....	....	..	....
2d "	5	.75	10	10.7	11.2	....	....	20.2	....	..	....
3d "	3.5	.75	10	11.2	7.8	....	....	28.0	....	..	....
4th "	4.0	.75	10	11.7	8.8	....	....	36.8	....	..	....
5th "	4.5	.75	10	12.5	9.7	....	....	46.5	....	..	....
6th "	3.0	.60	10	13.5	5.0	....	....	51.5	....	..	....
7th "	3.5	.60	10	14.5	5.6	....	....	57.1	....	..	....
8th "	3.0	.50	10	16.0	3.7	....	....	60.8	....	..	....
9th "	3.0	.50	10	17.5	3.3	....	....	64.1	....	..	....
10th "	1.0	.50	10	20.	0.9	....	....	65.0	....	..	....
*10th "	2.0	.50	10	18.0	2.0	36.5	24.15	67.0	28.3	31	32.6
Sewer in 12th St., from 10th Ave. to 15th Ave.											
†10th Avenue	4.0	.50	10	35	0.9	620	345	492	300	..	....

*Basin on 9th Ave. Time at 12th St., 240 min. No water admitted at 11th St.
†Continuation of 12th St. sewer. Q_1 from 10th Ave. sewer added.

obtained by calculating the discharge from each block for the time T plus 11, but in the case of a larger sewer, this would involve considerable work. We can, however, approximate this quantity very closely by the following method: If we take the time of collection at the last point as the time-length of the area and divide the total Q by the average rate of rainfall for that time we obtain the equivalent simple area. In this case the equivalent area is 28.3 and the time-length 20 mins. If we then multiply this equivalent area by the rate for an area of time-length, 20, at a time 11 mins. after the maximum or 31 mins., we obtain very closely the discharge of the sewer when $T = 35$ at Twelfth St. It will be noticed that the total $A\ I$ for the Tenth Ave. sewer is 24.15, a smaller figure than the equivalent area, 28.3. This is due to the fact that the greatest amount of territory is covered in the first portion of the 20 mins.; consequently a high rate of rainfall is collected from the greater portion of the area. If the collection were absolutely uniform the total $A\ I$ would, of course, have been equal to the equivalent A.

This, then, constitutes a very good check on the work, as in most cases where there is a large difference between the total $A\ I$ and the equivalent A, the reason is apparent on inspection of the area. In some of the cases that have come up with actual areas the equivalent A has been 30% greater than the total $A\ I$ and in other cases it has been 15% less. With small areas whose collection is fairly uniform the difference is almost nothing, thus showing that for such areas Kuichling's method of run-off determination holds.

The time occurrence of maximum flow is not always the time of collection from the furthermost point of an area, but in practice such cases are usually apparent at first glance. Where any doubt exists, however, it is best to determine this by trial.

No corrections have been attempted for the velocity in the sewer varying with the quantity discharged. Luckily this variation probably affects the results very little until the sewer begins to run less than half full. After the discharge falls below one-half of the maximum the velocity becomes much less and probably the actual quantity discharged is somewhat in excess of that obtained by the method described above. It would, however, be folly to attempt corrections for this before the actual time-lengths of the blocks are determined—a factor which has vastly more influence on the size of the sewer. If these time-lengths were known fairly accurately we could undoubtedly design a system with a very small factor of error, providing the imperviousness were absolutely known.

This method can also be very readily used so as to allow for the velocity and direction of the storm over the drainage area by merely adding to or subtracting from the time for which the discharge of the blocks are computed.

For instance, suppose it were known that the excessive storms moved in the direction of the flow in a sewer. It is clear that we should then subtract the time taken by the storm to travel the distance between two points of admittance of storm water from the time of running in the sewer and use the difference as the time distance between the areas. If the storm moved in a direction contrary to the flow in the sewer we would add the time instead of subtracting and if it moved obliquely to the sewer its component velocity would be used in the same manner.

It will, perhaps, be argued that as the time of collection from the blocks is not known at present, that any method of run-off determination depending upon this time is valueless, but as this time error is probably not more than 2 or 3 mins. at the most, the resulting error in the maximum flow is small in comparison to the error introduced by using any run-off formula.

For instance, an examination of McMath's formula proves absolutely that it cannot hold true even if the collection were uniform and the time of concentration depended upon the acreage and the average slope. Parmley, in his paper upon "Rainfall and Run-off" before the American Society of Civil Engineers deduced the rainfall curve of McMath's formula as $R = \dfrac{1.59\ r}{5\sqrt{(t-8)^2}}$ where $r = R$ in the formula, by considering the time of concentration to be $\dfrac{3.2\sqrt{A}}{\sqrt{8}} + 8$.

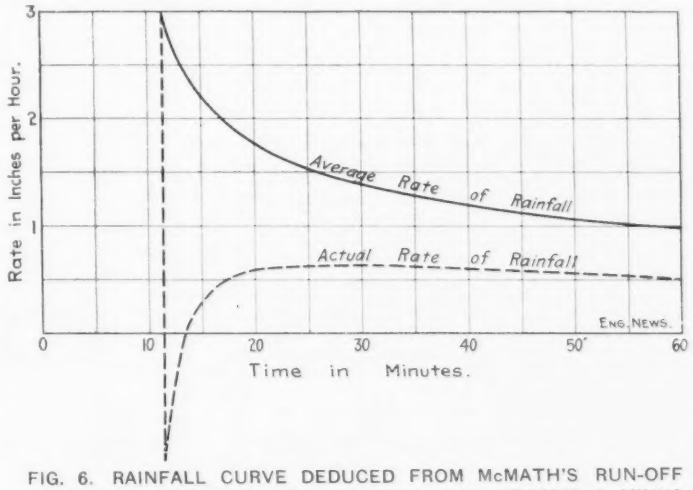


FIG. 6. RAINFALL CURVE DEDUCED FROM McMATH'S RUN-OFF FORMULA, SHOWING HOW RAINFALL MAY BECOME A MINUS QUANTITY.

McMath's Formula: $Q = A18\frac{1}{2}RC$.

If $R = 3$ and $t = \dfrac{3.2\sqrt{A}}{\sqrt{8}} + 8$.

Then $R' = \dfrac{4.77}{(t-8)^{\frac{1}{2}}}$ = Average Rate.

And $r = \dfrac{4.77 - \dfrac{1.91\ (t'+11.2)}{(t'+3.2)}}{(t'+3.2)^{\frac{1}{2}}}$ = Actual Rate referred to $t = 11.2$ as origin.

This is of course the average rate of rainfall. Now it is clear from the form of the equation that the curve passes through $\pm\ \infty$ when $t = 8$, which, strictly interpreted, would mean that the average rate of rainfall would be very high, indeed, for values of T a little greater than 8 minutes. If, however, we assume that the curve starts at the point $T = 11.2$ or the time required to drain 10 acres with $S = 10$, and take R as 3, the average rate for the 11.2 minutes becomes 3, which is a fair value. The curve does not, however, hold true beyond this point; for instance, the 3-in. rate for 11.2 minutes means that that precipitation is .56-in. Now, according to the curve the rate of rainfall for 15 minutes is 2.18 ins., which means a precipitation of only .545-in. Therefore, more rain is supposed to fall in 11.2 minutes

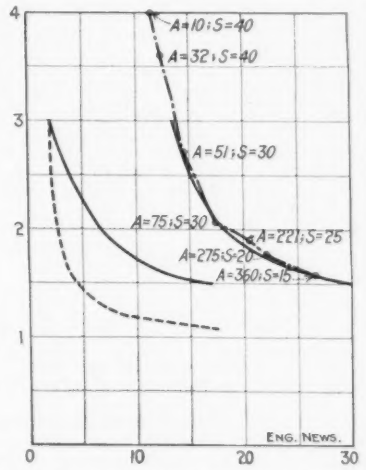


Fig. 7. A Further Illustration of the Unsatisfactory Character of the McMath's Formula.

than in 15 minutes—an evident absurdity.

This can very readily be shown by plotting the actual rainfall curve as derived from the average rainfall

$$R = \frac{1.59\ r}{5\sqrt{(t-8)^2}}.$$

If this represents the average rate of rainfall then if $R = \dfrac{4.77\ t}{(t-8)^{\frac{1}{2}}}$ represents the precipitation or integral curve of the rainfall. Then if the origin is transferred to 11.2 we have $R = \dfrac{4.77\ (t+11.2)}{(t+3.2)^{\frac{1}{2}}}$ and by differentiating obtain the actual rainfall curve,

$$R = \frac{4.77 - \frac{1}{2}\left(\dfrac{4.77\ (t+11.2)}{(t+3.2)}\right)}{(t+3.2)^{\frac{1}{2}}}$$

referred to $t = 11.2$ as the origin.

This curve and the average rainfall curve are plotted in the diagram, Fig. 6. It will be noticed that the rainfall drops away to a minus quantity at 11.2 minutes, but soon redeems itself by climbing rapidly to the ½-in. rate, where it remains for some time. This analysis may perhaps be met with the objection that the time is not really $\dfrac{3.2\sqrt{A}}{\sqrt{8}} + 8$, which in a way is well grounded. But, although this is true, it cannot be denied that it is conceivable that there are areas where the expression gives the time correctly. In fact, the writer plotted the results from an area whose time of collection corresponds very nearly to this. In Fig. 7 the crosses represent the rates of rainfall as given by McMath's formula and plotted according to the time required for concentration. The time of the first block was taken as 10 minutes, instead of the 8 minutes used by Parmley, with the result that the curve corresponds very closely with the curve he deduced, but is 2 minutes further from the origin. Now, as this initial time of running the first block is not known, but the time of running in the sewers is, the only error possible is one affecting the position of the origin. In order to overcome this, the curve was moved toward the origin until a point was reached where the actual rainfall curve would not have minus values and would decrease from the 3-in. rate in a fairly rational manner. This position was not reached until the time for the 3-in. rate was about 2 minutes. But, from the curve, the 3-in. rate applied to an area of about 40 acres; thus, in order for the results to hold, the time of concentration for 40 acres must be 2 minutes—something rather difficult to conceive. If the portion of the curve with values of R greater than 3 had been considered the result would have been even more absurd. It seems rather strange that so much time and labor should have been spent in the effort to establish a run-off formula. It is impossible, in the author's opinion, to devise one that will be even reasonably accurate without becoming unwieldy, as it would have to contain more variables than are allowed for in the present formulas and three of these variables are of such nature as to render it doubtful as to whether they could be embodied in a formula at all.

For instance, we have seen that it makes a great difference in what portion of an area the highest slopes and greatest degrees of imperviousness occur. Then, too, the shape and manner of collection influence the run-off to a marked extent. Formulas should never be used except as a rough guide to indicate what run-off may be expected and even here their use could probably be dispensed with by estimating the time of concentration and considering the area to be a simple area.

Nothing more flexible than the method I have outlined can be devised. Any rainfall curve may be used. The method adapts itself perfectly to all areas and any number of corrections and refinements can be introduced. For instance, the primary simple areas can be made as small as may be deemed necessary; the rainfall curve can be flattened to allow for the amount of water required to form a surface film and fill the gutters, being held back from the sewers for a time; the amount of water which goes to fill surface depressions can be subtracted from the beginning of the rainfall curve, etc.

Probably much of this refinement is not needed, but should it be found by experiment that any of the foregoing factors are important, they could easily be allowed for. Also, should it be found by rainfall gagings that the intensity of the storms varies considerably as they move over an area the rainfall curve could be increased or decreased as the time of concentration became greater. A series of experiments upon small areas, that could be made at comparatively small cost would determine most of these factors, but the rainfall gagings would have to be extended over a number of years in order to be of value.

The assumption of a percentage of run-off to provide for the expected development of an area presents a rather difficult problem. The typical development of the separate blocks can usually be estimated fairly well, but in many cases it is almost impossible to foresee just what portions of the territory will be developed in the time the sewers are expected to prove sufficient. Probably the ideal solution of the problem is to build the laterals and small trunks large enough to take care of the run-off from the expected typical development and intercept with sewers only large enough to provide for a part of this run-off and so designed as to be easily relieved in the future. When for any reason this scheme is not feasible the assumed imperviousness may be de-

creased in proportion to the area drained. For instance, suppose the typical development of the blocks or area "a" to be such as to give a coefficient of run-off C, then if the imperviousness from the whole area, A, were assumed as $\frac{C}{N}$ at the end of time the sewers are expected to last, the run-off could be reduced according to the expression

$$\frac{Q}{\sqrt[M]{\frac{A'}{a}}}$$

where A' = area drained by the sewer, Q = the run-off if the whole area were developed into typical blocks and M is taken so that

$$\sqrt[M]{\frac{A}{a}} = N;$$

or according to the expression

$$Q\left[1-\left(\frac{N-1}{N}\right)\left(\frac{A'-a}{A-a}\right)\right]$$

In the first case the total imperviousness would decrease from the maximum to the minimum in a hyperbola so that the decrease would be more rapid at first, and in the second case the decrease would be uniform, the locus being a straight line. Just what method should be used and what values assigned to A C and N for any particular area can only be determined by a careful study of conditions. It may be that some such factor as the first expression occurs in McMath's formula and explains, to a certain extent, why an analysis that does not take this into consideration leads to the minus rainfall, but inasmuch as the value of "M" in the formula is not known, that can hardly be argued by even the most enthusiastic as a reason for its use.

These remarks apply with equal force to the other formulas, as their form is identical.

With an intelligent use of even the incomplete data now at hand there can be no doubt that the additive method surpasses in accuracy any other method of run-off determination.

A GASOLINE TRACTION-ENGINE DRILL.—For several years portable drilling machines have been equipped with gasoline-engines, but not until recently have they been so designed as to use their gasoline motors in moving from place to place. The explosion-engine outfits generally have been recommended only for localities where water and fuel were scarce or poor. A gasoline traction type of well drill has now been put on the market by the Cyclone Drill Co., of Orrville, Ohio, for general use, irrespective of favorable or unfavorable conditions for steam drills. The drill is built on general lines worked out on steam machines, but with some adaptation to accommodate the explosion-engine drive.

As the machines had to be used on all sorts of ground it was considered necessary to mount the power apparatus so that none of the torsional stresses could fall on moving parts. The engine plant, forward and reverse clutches and all bearings therefore were put on a single cast iron sub-base. The traction drive is through a roller-bearing chain. The clutches to move the engine forward or backward are built on the lines of automobile transmission gear. Speed of the engine is varied, through a wide range, by a throttle valve. A battery and magneto are both used for igniting the charges and the cylinders carry two spark plugs. Cooling water is circulated by a gear-driven rotary pump. The machine, while moving along the road, is steered by a hand wheel at the rear end. This turns the front wheels through a worm gear; the wheels being mounted on bell-crank levers similar to automobile construction. A hinge joint is provided above the front axle so that excessive torsional stress in the machine frame is prevented in passing over bumps.

When ready to drill, the road clutch is thrown to a dead position and the engine is connected to the drilling end by a belt.

THE WATERWAYS COMMISSION provided in the River and Harbor bill passed during the closing hours of Congress has been appointed as follows: Senators—Gallinger, New Hampshire; Burton, Ohio; Piles, Washington; Smith, Michigan; Simmons, North Carolina, and Clarke, Arkansas. Representatives—Alexander, New York; Lorimer, Illinois; Stevens, Minnesota; Wanger, Pennsylvania; Sparkman, Florida, and Moon, Tennessee. The appointments were made by the Speaker of the House and the Vice-President.

THE MUNICIPAL DOCK AND LAND RECLAMATION scheme proposed for Newark, N. J. (Eng. News, July 23, 1908) has been held up for some time, owing to questions regarding the legality of the popular vote authorizing the expenditure of $1,000,000 for the purpose. The State Supreme Court has declared the election in question to have been legal. It is expected that the Board of Public Works will proceed with plans for the improvement.

Safety Valve Capacity.*

By PHILIP G. DARLING,† Assoc. Am. Soc. M. E.

The function of a safety valve is to prevent the pressure in the boiler to which it is applied from rising above a definite point, to do this automatically and under the most severe conditions which can arise in service. For this, the valve or valves must have a relieving capacity at least equal to the boiler evaporation under these conditions. If it has not this capacity, the boiler pressure will continue to rise, although the valve is blowing, with a strain to the boiler and danger of explosion consequent to over-pressure. Thus with the exception of a requisite mechanical reliability, the factor in a safety valve bearing the most vital relation to its real safety is its capacity.

It is the purpose of this paper to show an apparatus and method employed to determine safety valve lifts, giving the results of tests made with this apparatus upon different valves; to analyze a few of the existing rules or statutes governing valve size and to propose a rule giving the results of a series of direct capacity tests upon which it is based; to point out the application of this rule to special requirements, and finally to indicate its general bearing upon valve specifications.

Two factors in a safety valve geometrically determine the area of discharge and hence the relieving capacity; the diameter of the inlet opening at the seat and the valve lift. The former is the nominal valve size, the latter is the amount the valve disk lifts vertically from the seat when in action. In calculating the size of valves to be placed on boilers, rules which do not include a term for this valve lift, or an equivalent such as a term for the effective area of discharge, assume in their derivation a lift for each size of valve. Nearly all existing rules and formulas are of this kind which rate all valves of a given nominal size as of the same capacity.

DESCRIPTION OF VALVE-LIFT TESTS.—To find what lifts standard make valves actually have in practice and thus test the truth or error of this assumption that they are approximately the same for the same size valves, an apparatus has been devised and tests conducted upon different makes of valves. With this apparatus, not only can the valve lift be read at any moment to thousandths of an inch, but an exact permanent record of the lift during the blowing of the valve is obtained somewhat similar in appearance to a steam engine indicator card and of a quite similar use and value in analyzing the action of the valve.

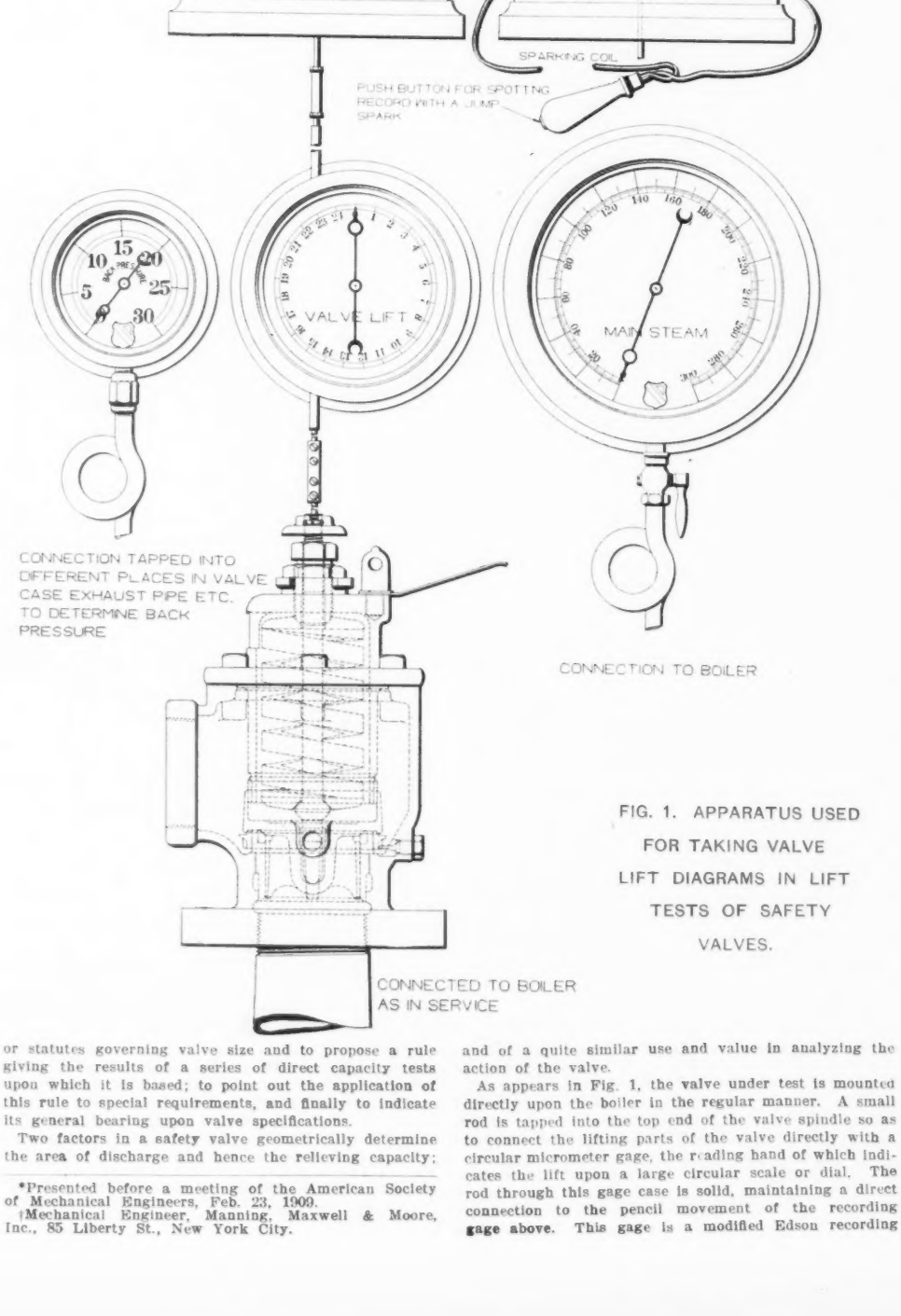

PAPER DRUM DRIVEN BY MOTOR THROUGH THE WORM AND WHEEL
FIXED CENTER
SHAFT DRIVEN BY A SMALL MOTOR
PAPER SPOOL
PENCIL MAKING RECORD
SPARKING COIL
PUSH BUTTON FOR SPOTTING RECORD WITH A JUMP SPARK
VALVE LIFT
MAIN STEAM
CONNECTION TAPPED INTO DIFFERENT PLACES IN VALVE CASE EXHAUST PIPE ETC. TO DETERMINE BACK PRESSURE
CONNECTION TO BOILER
CONNECTED TO BOILER AS IN SERVICE

FIG. 1. APPARATUS USED FOR TAKING VALVE LIFT DIAGRAMS IN LIFT TESTS OF SAFETY VALVES.

As appears in Fig. 1, the valve under test is mounted directly upon the boiler in the regular manner. A small rod is tapped into the top end of the valve spindle so as to connect the lifting parts of the valve directly with a circular micrometer gage, the reading hand of which indicates the lift upon a large circular scale or dial. The rod through this gage case is solid, maintaining a direct connection to the pencil movement of the recording gage above. This gage is a modified Edson recording

*Presented before a meeting of the American Society of Mechanical Engineers, Feb. 23, 1909.

†Mechanical Engineer, Manning, Maxwell & Moore, Inc., 85 Liberty St., New York City.

gage with a multiplication in the pencil movement of about 8 to 1, and with the chart drum driven by an electric motor of variable speed, giving a horizontal time element to the record. The steam pressures are noted and read from a large test gage graduated in pounds per square inch, and an electric spark device makes it possible to spot the chart at any moment, which is done to mark the points at which the different pressures are reached during the blowing of the valve. The actual lift equivalents of the pencil heights upon the chart are carefully determined so the record may be accurately measured to thousandths of an inch.

In testing, the motor driving the paper drum is started and the pressure raised in the boiler so that the valve pops, blows down and closes under the exact conditions of service, the pencil recording on the chart the history of its action.

With this apparatus, investigations and tests were started upon seven different makes of 4-in. stationary safety valves, and these tests were followed with similar ones upon nine makes of muffler locomotive valves, six of which were 3½-in. All of the valves were designed for and tested at 200 lbs. The stationary-valve tests were made upon a 94-HP. water-tube boiler made by the Babcock & Wilcox Co. The locomotive-valve tests were made upon locomotive No. 900 of the Illinois Central R. R., the valve being mounted directly upon the top of the main steam dome. This locomotive is of the consolidation type, having 50 sq. ft. of grate area and 2,953 sq. ft. of heating surface. Although a great amount of additional experimenting has been done, only the results of that mentioned above will be quoted in this paper. These lift records show (with the exception of a small preliminary simmer, which some of the valves have) an abrupt opening to full lift and an almost equally abrupt closing when a certain lower lift is reached. Both the opening and closing lifts are significant of the action of the valves.

The results of the 4-in. iron-body stationary-valve tests may be summarized as follows: Of the seven valves the average lift at opening was .079-in. and at closing .044-in.; or excluding the valve with the highest lifts, the averages were .07-in. at opening and .037-in. at closing. The valve with the lowest lifts had .031-in. at opening and .017-in. at closing, while that with the highest had .137-in. and .088-in. Expressing the opening lifts as percents of the highest, the lowest had 31.4%, the next larger 40.8% and the next 46.6%. Of the six 3½-in. muffler locomotive valves, the summarized lifts are as follows: Average of the six valves, .074-in. at opening and .043-in. at closing; average excluding the highest, .061-in. at opening and .031-in. at closing. The lowest-lift valve had .04-in. opening and .023-in. closing; the highest, .140-in. opening and .102-in. closing. As percents of the highest, the lowest-lift valve was 36.4%, the next larger 39.8% and the next 46.4%.

The great variation (300%) in the lifts of these standard valves of the same size is startling and its real significance is apparent when it is realized that under existing official safety-valve rules these valves, some of them with less than one-third the lift and capacity of others, receive the same rating and are listed as of equal relieving value. Three of these existing rules are given as an illustration of their nature; the U. S. Supervising Inspectors' Rule, the Boiler Inspection Rule of Philadelphia and the Rule of the Board of Boiler Rules of Massachusetts.

RULE OF THE UNITED STATES BOARD OF SUPERVISING INSPECTORS.—

$$A = .2074 \frac{W}{P}$$

A = area of safety valve in sq. ins. per sq. ft. of grate surface.
W = lbs. of water evaporation per sq. ft. of grate per hour.
P = boiler pressure (absolute).

In 1875 a special committee was appointed by this board to conduct experiments upon safety valves at the Washington Navy Yard. Although the pressures used in these experiments (30 to 70 lbs. per sq. in.) were too low to make the results of much value to-day, one of the conclusions reported is significant:

First: That the diameter of a safety valve is not an infallible test of its efficiency.
Second: That the lift which can be obtained in a safety valve, other conditions being equal, is a test of its efficiency.

The present rule of the board as given above, formulated by Mr. L. D. Lovekin, Chief Engineer of the New York Shipbuilding Co., was adopted in 1904. Its derivation assumes practically a 45° seat and a valve lift of 1/32 of the nominal valve diameter. The discharge area in this rule is obtained by multiplying the valve lift $\frac{D}{32}$ by the valve circumference (πD) and taking but 75% of the result to allow for the added restriction of a 45° over a flat seat. The 75% equals approximately the sine of 45°, or .707. This value for the discharge area, ($.75\ \pi \frac{D^2}{32}$) is substituted directly into Napier's formula for the flow of steam, $W = A \frac{P}{70}$. In the valves to which this rule is applied, the following lifts are assumed to exist:

1-in. valve	.03-in.	4-in. valve	.13-in.
2-in. valve	.06-in.	5-in. valve	.16-in.
3-in. valve	.09-in.	6-in. valve	.19-in.

Referring back to the valve lifts as given in the eighth paragraph, it is seen that the highest lift agrees very closely with the lift assumed in the rule. If the valve-lifts of the different designs were more uniformly of this value, or if the rule expressly stipulated either that the lift of 1/32 of the valve diameter must actually obtain in valves qualifying under it or that an equivalent discharge area be obtained by the use of larger valves, the rule would apply satisfactorily. However, the lowest-lift valve tested actually has but one-fourth this lift, the next larger less than one-half; and the average lift of all but the highest-lift valve (which average is .07-in.) is but 56% of the lift assumed in the rule for 4-in. valves.

MASSACHUSETTS RULE OF 1908.—

$$A = \frac{W\ 70}{P}\ 11$$

A = area of safety valve in sq. in. per sq. ft. of grate surface.
W = lbs. of water evaporation per sq. ft. of grate surface per second.
P = boiler pressure (absolute).

One of the most recently issued rules is that contained in the pamphlet of the new Massachusetts Board of Boiler Rules, dated March 24, 1908. This rule is merely the United States rule given above with a 3.2% larger constant and hence requires valves larger by that amount. The evaporation term is expressed in pounds per second instead of per hour and two constants are given instead of one, but when reduced to the form of the United States rule it gives $A = .214 \frac{W}{P}$. Figuring this back as was done above with the United States rule and taking the 75% of the flat seat area as before shows that this rule assumes a valve lift of 1/33 of the valve diameter, instead of the 1/32 of the U. S. rule. Since this changing of the assumed lift from 1/32 to 1/33 of the valve diameter is the only difference between the two rules, the inadequacy of the U. S. rule just developed exists equally in this more recent rule of the Massachusetts Board.

PHILADELPHIA RULE.—

$$A = \frac{22.5\ G}{P\ 8.62}$$

A = total area of safety valve or valves in sq. ins.
G = grate area in sq. ft.
P = boiler pressure (gage).

The Philadelphia rule now in use came from France in 1868, being the official rule there at that time and having been adopted and recommended to the city of Philadelphia by a specially appointed committee of the Franklin Institute, although this committee frankly acknowledged in its report that it "had not found the reasoning upon which the rule had been based." The area (A) of this rule is the effective valve opening or, as stated in the Philadelphia ordinance of July 13, 1868, "the least sectional area for the discharge of steam." Hence if this rule were to be applied as its derivation by the French requires, the lift of the valve must be known and considered whenever it is used. However, the example of its application given in the ordinance, as well as that given in the original report of the Franklin Institute Committee which recommended it, shows the area (A) applied to the nominal valve opening. In the light of its derivation, this method of using it takes as the effective discharge area the valve opening itself, and the error thus introduced is very great. Such use, as specifically stated in the report of the committee above referred to, assumes a valve lift at least one-fourth of the valve diameter, i. e., the practically impossible lift of 1 in. in a 4-in. valve.

The principal defect of these rules in the light of the preceding tests is that they assume that valves of the same nominal size have the same capacity and rate them the same without distinction, in spite of the fact that in actual practice some have but one-third of the capacity of others. There are other defects, as have been shown, such as varying the assumed lift directly as the valve diameter, while in reality with a given design the lifts are more nearly the same in the different sizes, not varying nearly as rapidly as the diameters. And further than this, the actual lifts assumed for the larger valves are nearly double the actual average obtained in practice.

The direct conclusion is this—that existing rules and statutes are not safe to follow. Some of these rules in use were formulated before spring safety valves were invented, at a time when 120 lbs. was considered high pressure, and have not been modified since. None of these rules takes account of the different lifts which exist in the different makes of valves of the same nominal size, and they thus rate exactly alike valves which actually vary in lift and relieving capacity by over 300%. It would therefore seem the duty of all who are responsible for steam installation and operation to no longer leave the determination of safety valve size and selection to such statutes as may happen to exist in their territory, but to investigate for themselves.

THE BARBERTON CAPACITY TESTS.—The elements of a better rule for determining safety valve size exist in Napier's formula for the flow of steam combined with a consideration of the actual discharge area of the valve as determined by its lift. In "Steam Boilers" by Peabody & Miller, a method involving these principles of determining the discharge of a safety valve is used. The uncertainty of the coefficient of flow, that is of the constant to be used in Napier's formula when applied to the irregular steam discharge passages of safety valves, has probably been largely responsible for the fact that this method of obtaining valve capacities has not been more generally used. In order to determine the value of this constant, or coefficient of flow, and to find out how it is affected by variations in valve design and adjustment, an extended series of tests have recently been conducted at the Stirling Department of the Babcock & Wilcox Co., at Barberton, Ohio.

A 373-HP., class K, No. 20 Stirling boiler, fired by a Stirling chain grate with a total grate area of 101 sq. ft., was used for the tests. This boiler contained a U-type of superheater designed for a superheat of 50° F. The water feed to this boiler was measured in calibrated tanks and pumped (steam for the pump being furnished

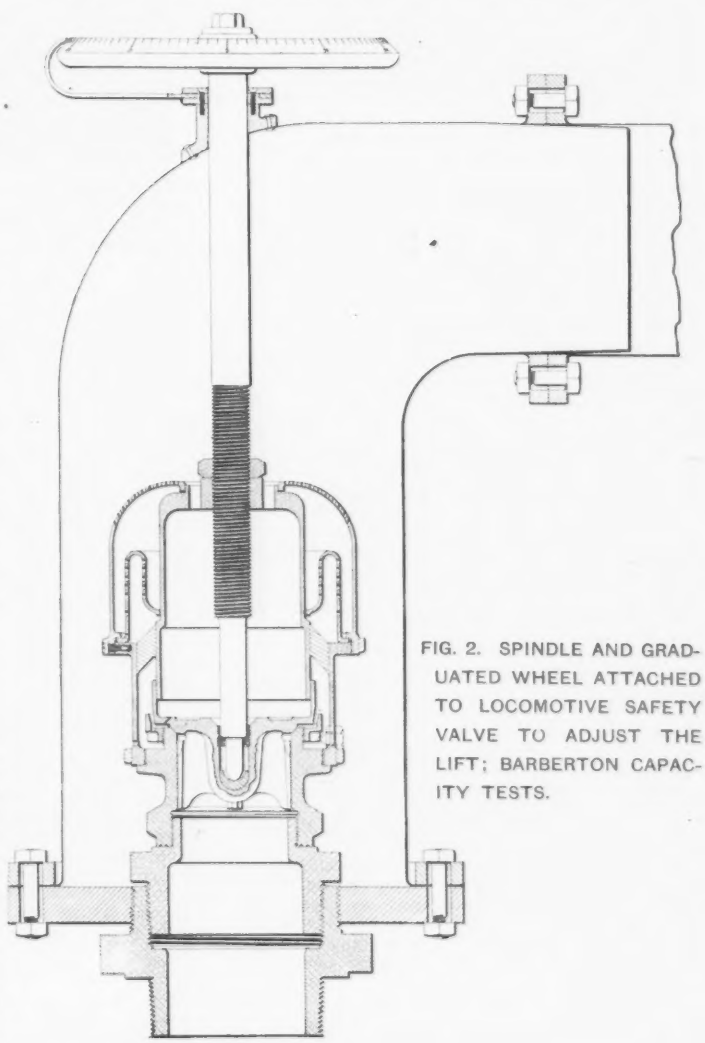


FIG. 2. SPINDLE AND GRADUATED WHEEL ATTACHED TO LOCOMOTIVE SAFETY VALVE TO ADJUST THE LIFT; BARBERTON CAPACITY TESTS.

from another boiler) through a pipe line which had been blanked wherever it was impossible to use stop valves and intermediate open drips to insure that there was no leakage. The entire steam discharge from the boiler was through the valve being tested, all other steam connections from the boiler being either blanked or closed with stop valves beyond which were placed open drip connections to reveal any leakage. A constant watch was kept throughout the testing upon all points of the feed and steam lines to insure that all water measured in the calibrated tanks was passing through the valves under test without intermediate loss.

The valves tested consisted of a 3-in., a 3½-in., and a 4-in. iron stationary valve and 1½-in., 3-in., and 3½-in. locomotive valves, the latter with and without mufflers. These six valves were all previously tested and adjusted on steam. Without changing the position of the valve disk and ring, the springs of these valves were removed and solid spindles threaded with a 10-pitch thread were inserted from above through the valve casing. Upon the top end of these spindles were placed wheels graduated with 100 equal divisions. Fig. 2 shows the arrangement used with the locomotive valves, the spindle and graduate wheel being similar to that used with the stationary valves. By this means, the valve lift to thousandths of an inch was definitely set for each test, eliminating the necessity for continual valve-lift readings with their accompanying errors.

In conducting the tests, three hours' duration was selected as the minimum time for satisfactory results. Pressure and temperature readings were taken every three minutes, water readings every half hour. A man stationed at the water glass regulated the feed to the boiler to maintain the same level in the boiler during the test, other men were stationed, one at the water tanks, one firing and one taking the pressure and temperature readings. Pressure readings were taken from two test gages connected about 4 ins. below the valve inlet, the gages being calibrated both before and after the series of tests was run.

Tests numbered 1 to 5 were preliminary runs of but one hour or less duration apiece, and the records of them are therefore omitted in the accompanying table, which gives the lifts, discharge areas, average pressure and superheat, and steam discharge in pounds per hour for each of the remaining 24 tests. The discharge areas have been figured for 45° seats from the formula $A = 2.22\ D\ L + 1.11\ L^2$; where A equals the effective area in square inches, D equals the valve diameter in inches, and L equals the valve lift in inches. In tests 8 and 23, where the widths of valve seat were .225-in. and .185-in., respectively, and the valves lifted slightly more than the depth of the valve seat, the area was figured for this condition.

As previously stated the application of these results is in fixing a constant for Napier's formula as applied to safety valves. The formula is $W = A\ \frac{P}{70}$ in which W equals pounds discharged per second, P equals the absolute steam pressure behind the orifice or under the valve, and A equals the effective discharge opening in square inches. This may be stated as $E = C\ A\ P$; in which E equals the pounds steam discharged per hour and C is a constant. Since E, A and P are given for the above tests, C is directly obtainable.

RESULTS OF TESTS.—Computing the values of this constant leads to the following conclusions:

1st. Increasing or altering the steam pressure from approximately 50 to 150 lbs. per sq. in. (tests 14 and 10) does not affect the constant. This merely confirms the applicability of Napier's formula in that respect.

2d. Radically changing the shape of the valve disk outside of the seat at the huddling, or throttling, chamber, so-called, does not affect the constant or discharge. In test No. 15 the valve had a downward projecting lip, as in Fig. 1, deflecting the steam flow through nearly 90°, yet the discharge was practically the same as in tests No. 10 and No. 14, where the lip was cut entirely away, as in Fig. 2, giving a comparatively unobstructed flow to the steam discharged.

3d. Moving the valve adjusting ring through far more than its complete adjustment range does not affect the constant or discharge. (Tests No. 16 and No. 17.)

4th. The addition of the muffler to a locomotive valve does not materially alter the constant or discharge. There is but 2% difference between tests No. 10 and No. 13.

5th. Disregarding the rather unsatisfactory 1½-in. and 3-in. locomotive-valve tests, the results for the different sizes of valves tested show, when plotted to given lifts, a variation in the constant of about 4%.

6th. There is a slight uniform decrease of the constant when increasing the valve lifts.

The variations indicated in the last two conditions are not large enough to materially impair the value of a single constant obtained by averaging the constants of all the 24 tests given in the table. The selection of such a constant is obviously in accord with the other four conditions mentioned. This average constant is 47.5, giving as the formula $E = 47.5\ A\ P$. Its value for the standard orifice of Napier's formula is 51.4, of which the above is 92½%.

To make this formula more generally serviceable, it should be expressed in terms of the valve diameter and lift, and can be still further simplified in its application by expressing the term E (steam discharged or boiler evaporation per hour) in terms of the boiler heating surface or grate area. For the almost universal 45° seat, the effective discharge area is, within a close approximation, $A = L\ sin\ 45°\ \pi\ D$ in which L equals the valve lift vertically in inches and D the valve diameter in inches. Substituting this expression for A in the above formula gives $E = 47.5\ L\ sin\ 45°\ \pi\ D\ P$, or $E = 105.5\ L\ D\ P$.

The mathematical approximation referred to consists in multiplying the term ($L\ sin\ 45°$) by ($\pi\ D$) instead of by the exact value ($\pi\ D + ½\ L$). To find directly the effect of this approximation upon the above constant, the values for E, L, D, and P from the tests have been substituted into the above formula and the average constant re-determined, which is 108.1. The average lift of all the tests is .111 in. Plotting the constants obtained from the above formula in each test, as ordinates, to valve lifts, as abscissas, gives the amount of the slight inclination referred to above in conclusion 6, and plotting a line with this same inclination through the above obtained average constant 108.1, taken at the .111-in. average lift we obtain, at a maximum lift of say .14-in., a constant of just 105. At lower lifts this is slightly larger. Hence 105 would seem to be the conservative figure to adopt as a constant in this formula for general use, giving the equation

$$E = 105\ L\ D\ P.$$

This transposed for D gives

$$D = .0095\ \frac{E}{L\ P}$$

Note than the nominal valve area does not enter into the use of this formula and that if a value of 12, for

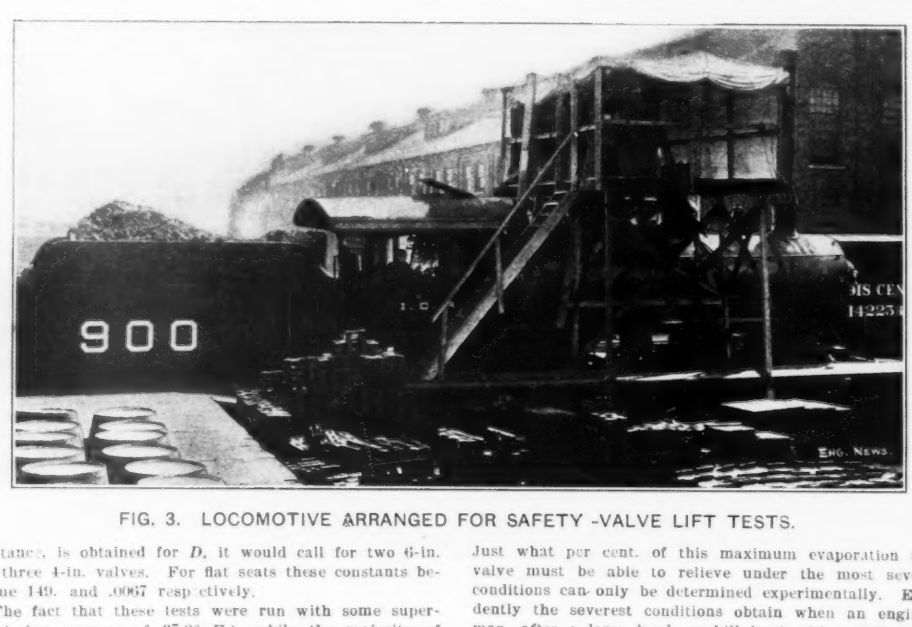


FIG. 3. LOCOMOTIVE ARRANGED FOR SAFETY-VALVE LIFT TESTS.

instance, is obtained for D, it would call for two 6-in. or three 4-in. valves. For flat seats these constants become 149. and .0067 respectively.

The fact that these tests were run with some superheat (an average of 37.2° F.), while the majority of valves in use are used with saturated steam, would, if any material difference exists, place the above constants on the safe side. The capacities of the stationary and locomotive valves, the lift-test results of which are summarized in the eighth paragraph, have been figured from this formula, taking the valve lifts at opening, with the following results: Of the seven 4-in., iron-body stationary valves the average capacity at 200 lbs. pressure is 7,370 lbs. per hr., the smallest capacity valve (figured for a flat seat) has a capacity of 3,960 lbs., and the largest 12,400 lbs. Of the six 3½-in. muffler locomotive valves at 200 lbs. pressure the average capacity is 6,060 lbs. per hr., the smallest 4,020 lbs., the largest 11,050 lbs.

To make the use of the rule more direct where the evaporation of the boiler is only indirectly known it may be expressed in terms of the boiler heating surface or grate area. This modification consists merely in substituting for the term E (lbs. of total evaporation) a term H (square feet of total heating surface) multiplied by the number of pounds of water which the boiler will evaporate per sq. ft. of heating surface. Evidently the value of these modified forms of the formula depends upon the proper selection of average boiler evaporation figures for different types of boilers and also upon the possibility of so grouping these boiler types that average figures can be thus selected. This modified form of the formula is

$$D = C\ \frac{H}{L\ P}$$

in which H equals the total boiler heating surface in square feet, and C is a constant.

Values of the constant for different types of boilers and service have been selected. These constants are susceptible of course to endless discussion among manufacturers and it is undoubtedly more satisfactory where any question arises, to use the form containing E itself. Nevertheless the form containing the term H is more direct in its application and it is believed that the values given below for the constant will prove serviceable. In applying the formula in this form rather than the original one containing the evaporation term E, it should be remembered that these constants are based upon average proportions and hence should not be used for boilers in which any abnormal proportions or relations between grate area, heating surface, etc., exist.

For cylindrical multitubular, vertical and water-tube stationary boilers a constant of .068 is suggested. This is based upon an average evaporation of 3¼ lbs. of water per sq. ft. of heating surface per hr. with an overload capacity of 100%, giving 7 lbs. per sq. ft. of heating surface, the figure used in obtaining the above constant.

For water-tube marine and Scotch marine boilers, the suggested constant is .095. This is based upon an overload or maximum evaporation of 10 lbs. per sq. ft. of heating surface per hr.

For locomotives the value .055 for the constant was determined experimentally as explained below. In locomotive practice there are special conditions to be considered which separate it from regular stationary and marine work. In the first place the maximum evaporation of a locomotive is only possible with the maximum draft obtained when the cylinders are exhausting up the stack, at which time the throttle is necessarily open. The throttle, being open, is drawing some of the steam and therefore the safety valves on a locomotive can never receive the full maximum evaporation of the boiler. Just what per cent. of this maximum evaporation the valve must be able to relieve under the most severe conditions can only be determined experimentally. Evidently the severest conditions obtain when an engineman, after a long, hard, up-hill haul with a full glass of water and full pressure, upon reaching the top of the hill suddenly shuts off his throttle and injectors. The work on the hill has gotten the engine steaming to its maximum and the sudden closing of throttle and injectors forces all the steam through the safety valves. Of course, the minute the throttle is closed the steaming quickly falls off and at just that moment comes the severest test upon the valves.

A large number of service tests have been conducted to determine this constant. The size of valves upon a locomotive has been increased or decreased until one valve would just handle the maximum steam generation and then, the locomotive heating surface being known, the formula was figured back to obtain the constant. Other special conditions were considered, such as the liability in locomotive practice to a not infrequent occurrence of the most severe conditions; the exceptionally severe service which locomotive safety valves receive; and the advisability in the case of locomotives to provide a substantial excess valve capacity.

As to the method of applying the proposed safety valve capacity rule in practice, manufacturers could be asked to specify the capacity of their valves, stamping it upon them as the opening and closing pressures are now done. This would necessitate no extra work further than the time required in the stamping, because for valves of the same size and design giving practically the same lift, this would have to be determined but once, which of itself is but a moment's work with a small portable lift gage which is now manufactured. The specifying of safety valves by a designing engineer would then be as definite a problem as is that of other pieces of apparatus. Whatever views are held as to

the advantages of high or low lifts, there can be no question, it would seem, as to the advantage of knowing what this lift actually is, as would be shown in this specification by manufacturers of the capacity of their valves. Further, as to the feasibility of adopting such a rule (which incorporates the valve lift) in statutes governing valve sizes, this would involve the granting and obtaining by manufacturers of a legal rating for their valve designs based upon their demonstrated lifts.

This paper has dealt with but one phase of the subject of safety valves in order that its conclusions might be drawn more clearly. The apparatus and tests shown indicate that the lifts and capacities of different makes of valves of the same size and for the same conditions vary as much as 300% and that there is, therefore, the liability of large error in specifying valves in accordance with existing rules and statutes because these rules, as already shown, rate all valves of one size as of the same capacity irrespective of the variation in lift. The simple rule given in this paper and based upon an extended series of direct capacity tests, avoids this error by incorporating a term for the valve lift.

Discussion.

The meeting of the American Society of Mechanical Engineers at which Mr. Darling's paper was read, opened with an introductory paper by Mr. Frederic M. Whyte, General Mechanical Engineer of the New York Central Lines, which presented the safety valve problem as met with in locomotive practice.

The capacity of a safety valve depends upon the circumference and angle of its seat and upon the amount of lift, or distance the valve rises above the seat when blowing. The valve capacity which is to be provided on a given stationary boiler should equal the maximum possible evaporation of which the boiler is capable under conditions when the valve would open. In the case of the locomotive boiler, however, the problem is complicated by the fact that the maximum evaporation occurs when the draft is augmented by the exhaust from the cylinders. Since the throttle must of necessity be open at such a time, the locomotive safety valve can never be called upon to discharge for an appreciable length of time the maximum capacity of the boiler. The worst condition occurs at the top of a stiff upgrade when the throttle is suddenly closed with the boiler at maximum capacity.

Mr. L. D. Lovekin, Chief Engineer of the New York Ship Building Co., then presented a paper outlining the characteristic difficulties arising in the application of safety-valves to marine boilers. Safety-valve connections in marine practice are in some cases 100 ft. or more in length and it is the common rule to make these pipes one-half the diameter of the valves they serve.

Mr. Lovekin was followed by Mr. Philip G. Darling, Mechanical Engineer of the Ashcroft Mfg. Co., who read his paper as reproduced above.

Mr. Albert C. Ashton, of the Ashton Valve Co., remarked that it had not been proved that high-lift valves are a success in actual use. High-lift valves have been known to lift water out of boilers, have caused leaky tubes and have hammered themselves to pieces after a short period of service on locomotives. By high-lift valves are meant those showing about twice the standard lift. Mr. Ashton expressed the opinion that the Society ought to decide upon and authorize a standard formula for safety valves.

Mr. A. B. Carhart, Superintendent of the Crosby Steam Gage & Valve Co., presented a paper on the subject of safety-valve springs. After an unnecessarily prolonged dissertation on Hooke's law, this paper set forth the importance of the part played by the spring in safety-valve operation. The efficiency of the spring determines the satisfactory operation of the valve. Spring proportions are calculated for the total load on the valve disk with valve closed, using the smallest valve diameter in the case of conical valves. The lift to be given the valve determines the requisite deflection of the spring. The load for which the valve is set should be carried at two-thirds to three-fourths of the total free compression. Safety-valve springs should be able to stand any number of complete compressions without permanent set. Compressing to 70% of the total free compression should produce a fibre stress of 60,000 to 70,000 lbs. per sq. in. in the steel, as the spring has the best efficiency at about this stress. If the wire for the spring is too large the tendency toward permanent set will be increased because the set is due to flexure rather than torsion and the stress of flexure increases with the size of the wire. Sticking of valves is due more to binding friction in the disk guides than to rusting of the valve seat. To correct this tendency, the diameter of cylindrical guides should be reduced.

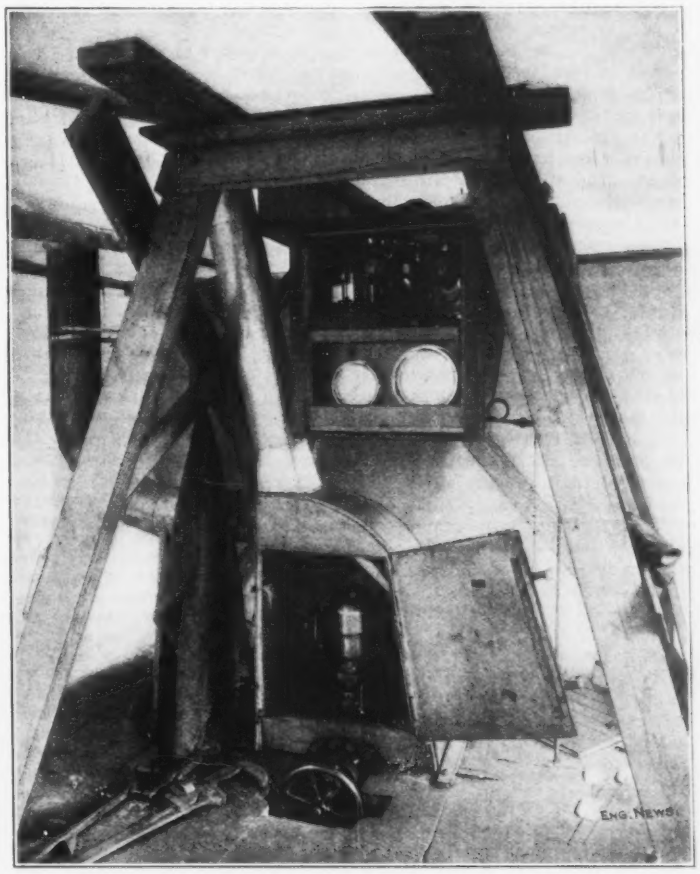


FIG. 4. NEARER VIEW OF APPARATUS FOR TAKING SAFETY-VALVE-LIFT DIAGRAMS ON LOCOMOTIVE SHOWN IN FIG. 3.

Mr. A. A. Cary, of New York, in discussing Mr. Carhart's paper later in the evening, said that

SAFETY VALVE CAPACITY TESTS.

(Run at the Stirling Works of the Babcock and Wilcox Co., Barberton, Ohio, Nov. 30 to Dec. 23, 1908.)

Test Number.	Duration of Test. Hrs.	Size and Type of Valve.	Adjustment Remarks.	Valve lift, ins.	Pressure, lbs. per sq. in.	Superheat. Deg. F.	Discharge per hr. lbs. of steam.	Discharge area (Note 1) sq. in.	Remarks.
6	3	4" R. F. iron stationary	Regular adj., exh. piped	.0695	151.7	43.6	5,120	.6226	No back pressure.
7	3	"	"	.139	145.4	45.1	8,600	1.255	Back pressure, 2 lbs.
8	3	"	"	.180	135.7	49.2	11,020	1.704	Back pres. 3 lbs.; max. pres.; lift > depth of seat.
9	3	"	"	.1045	149.4	41.9	7,290	.9400	Back pressure, 1 lb.
10	2½	3½" Locomotive Form R.	Regular adj., without muffler	.140	146.7	39.0	8,685	1.109	Tests 10-12 inclusive with an open locomotive valve.
11	3	"	"	.070	152.5	38.0	4,670	.5493	
12	3	"	"	.105	150.3	41.2	6,780	.8290	
13	3	Form S.	with muffler	.1395	146.3	38.1	8,400	1.106	Muffler valve in this following locomotive tests.
14	2	"	"	.140	52.2	51.3	3,260	1.108	Test at low steam pressure.
15	2½	Same except with lipped disk	"	.140	146.4	39.0	8,600	1.109	Different type of valve disk.
16	3	4" R. F. iron stationary	Regular adj., exh. piped	.140	138.5	42.3	8,770	1.265	No back pressure, repetition of Test No. 7.
17	3	"	Adj. ring one turn	.140	142.0	50.1	8,900	1.265	Back pressure, 3 lbs.; adj. ring position changed.
18	2	1½" Locomotive Form S.	1/16 above reg. posi.	.107	140.8	23.0	2,515	.4272	Tests 18-21 inclusive unsatisfactory as the valve was too small for the boiler used.
19	1	"	Regular adj., with muffler	.060	151.2	None	1,550	.2038	
20	2½	"	"	.075	146.3	None	2,025	.2560	
21	2½	"	"	.075	147.7	None	1,975	.2560	
22	1½	3½" R. F. iron stationary	Regular adj., exh. piped	.070	146.8	42.6	4,320	.5493	No back pressure.
23	3	"	"	.140	139.9	43.6	8,360	1.136	No back pressure, lift > depth of seat.
24	3	"	"	.105	141.6	48.7	6,300	.8280	Tests 24-27 inclusive, no back pressure.
25	3	3" R. F. iron stationary	"	.130	140.1	48.4	6,370	.8846	
26	3	"	"	.100	142.8	45.6	5,160	.6770	
27	2	"	"	.070	142.4	29.5	3,705	.4716	
28	3	3" Locomotive Form S.	Regular adj., with muffler	.130	138.4	48.7	7,000	.8846	
29	3	"	"	.090	139.3	43.9	4,950	.6034	

Note 1.—The valves all having 45° bevel seats these areas are obtained from formula

$$a = 2.22 \times D \times l + 1.11 \times l^2$$

except where as in tests Nos. 8, 18, 23, 25, the valve lift is greater than the depth of the valve seat where the following formula is used.

$$a = 2.22 \times D \times d + 1.11 \times d^2 + \pi \times D \times (l - d)$$

a = discharge area (sq. in.)
D = valve dia. (in.)
l = valve lift (in.)
d = depth of valve seat (in.)

Note 2.—The four wings of the valve feather or disk probably reduce the flow slightly, but as these are cut away at the seat a definite correction of the exit areas for them is impossible. Further the formula constants are desired for the valves as made.

round wire is better than square for safety-valve springs because the square wire can scarcely be evenly tempered on account of the sharp corners. Extension springs are more reliable than compression springs because the load can be more definitely applied axially. Springs should not be subjected to temperatures above 450° F.

Mr. Carhart was followed by Mr. E. A. May, of the American Radiator Co., who read a paper in which he discussed the application of safety valves to cast-iron, low-pressure heating boilers. In choosing valves for such boilers it is necessary to consider both the amount and character of the heating surface and the number of square feet of radiation supplied with steam from the boiler. The automatic draft regulators provided on nearly all heating boilers make it probable that the safety valve will be called into use only at rare intervals. Safety valves on heating boilers are regularly set to operate at from 12 to 15 lbs. pressure and the common operating pressure is less than 5 lbs. Mr. May called attention to the fact that existing rules and experiments on valve capacity do not include pressures below 20 lbs. per sq. in., so that the selection of valves for heating boilers is even more uncertain than for boilers working at higher pressures.

Some notes sent in by Mr. F. J. Cole, Consulting Engineer of the American Locomotive Co., suggested that a safety-valve formula in terms of square feet of heating surface—and this is the type of formula most generally usable—should take into account the relative evaporating power of the various portions of the heating surface. A square foot of heating surface in the fire-box, for example, should not be treated as equivalent to a square foot of flue area. When the present type of locomotives was first introduced, 3-in. safety valves were adopted and this size has been retained, although the capacity of the boilers has been doubled. The evaporation per square foot of heating surface varies, in locomotive boilers, from 6 to 15 lbs.

Dr. Chas. E. Lucke, Professor of Mechanical Engineering of Columbia University, suggested that in preparing a formula for safety valves, consideration should be given to the effect of the time element. It is commonly recognized that a sudden stress is the most disastrous and it should be ascertained whether or not a sudden rise of pressure might not give rise to a momentary excess over that for which the valve was set.

President Jesse M. Smith remarked that care should be taken not to have the valves so large as to reduce the pressure below that for the regular operation of the boiler. A sudden reduction of pressure might result in serious damage to the boiler. In France, he believed, a maximum as well as a minimum size of valve was fixed by law.

Mr. H. C. McCarty, of the Coale Muffler & Safety Valve Co., of Baltimore, Md., stated that, so far as locomotives are concerned, there is no advantage in a "high-lift" valve. Such a valve damages not only itself, but the boiler as well. There is no advantage gained with a valve of given diameter by increasing the lift about the standard amount (1/32 of the valve diameter). On the contrary, too high a lift may cause an action similar to water hammer. Any disturbance of the water level in a modern locomotive is a serious thing, as dry steam is absolutely essential. The water crest in a locomotive boiler is highest at the turn of a grade just when the safety valve is apt to operate and under such conditions a high-lift valve may so disturb the water level as to cause priming and consequent breaking of cylinder heads. The location of the valve is an important point. It should be placed, on locomotives, as high as the clearance will permit and the connections to the steam dome should be as short as possible.

A STATE LICENSE FOR CIVIL ENGINEERS and land surveyors is provided for in a bill now pending before the legislature of the State of Washington. Licenses are to be issued for either or both of the above professions and fees charged and bonds required for each license. An examining board to pass upon the qualifications of each applicant and to issue licenses is provided.

The New 85-lb. Rail Section of the Canadian Pacific Ry.

In 1908 the Canadian Pacific Ry. adopted an 85-lb. rail of a new form of section designed by F. P. Gutelius, M. Am. Soc. C. E., General Superintendent of the Lake Superior Division. The section is shown in the accompanying cut, and the company has now 85,000 tons of these rails in the track. The new section embodies some of the recommendations of the rail committee of the American Society of Civil Engineers in regard to modifying the original Am. Soc. C. E. sections for heavy rails (Engineering News, Jan. 23, 1908). It has also some special features of its own. These rails and the specifications under which they are manufactured were dealt with recently by Mr. Gutelius in a paper read before the Canadian Railway Club, and we give herewith an abstract of this paper. We also give a table comparing the dimensions of some 85-lb. rail sections, and in our editorial columns we have discussed the special features of the new rail as compared with some other rails of the same weight.

In the new section the radius of the web has been decreased from 12 ins. to 8 ins., thus giving a wider web where it joins the head and the base. The sides of the head are slightly inclined, and the radius of the top of the head is 8 ins. instead of 12 ins.

The new section differs from that recommended by the American Railway Association* in that the base has not been narrowed. The writer does not feel that in the redistribution of material the narrowing of the base is justified. It makes the rail more unstable, introducing an element of danger which cannot be counterbalanced by the advantage that would be gained by the more uniform cooling of the narrower flange.

The advantages of this section, from the mill standpoint, are that the finished rail, when approaching the hot saws, is of more even temperature in all parts of the section. As a result, the temperature of the head is very much less than in the old section, giving a finer grain of steel, therefore greater wearing quality. The more equal distribution of material between the head and base simplifies the cold straightening process to such an extent that the mill people advise that the work of straightening is less than 40% of what was required in the old section. The straightening of rails under the cold press is a punishment which seriously impairs the strength of the rail, and frequently appears to open defects or start fractures which would never be known in ordinary wear during the life of the rail.

In designing a rail for use in Canada the conditions of winter roadbed must be provided for. The roadbed, when frozen, is absolutely rigid. In the process of freezing, ties under which there is a quantity of moisture heave on account of the action of the frost to such an extent as to require wooden shims on the adjoining ties to maintain an even bearing for the rail, and give proper surface to the track. At the time the shimming becomes necessary the rails must bend sufficiently to receive their proper support from the low ties, and if the rail is too rigid, or too hard, it is liable to break.

For this reason, we deemed it wise to limit the height of the rail to 5 or 5⅛ ins., and place the additional strength on those portions of the rail which are most liable to crack or break. This conclusion was arrived at after an experience of seven years, with about 50 miles of Am. Soc. C. E. 100-lb. rail. With an equal amount of heaving and equally rigid track, more square breaks occurred with the 100-lb. rails than with an equal mileage of Am. Soc. C. E. 80-lb. rails, handling the same traffic, under like climatic conditions.

In the composition specified, the average carbon for Bessemer rails is 0.58%, and for open-hearth rails is not less than 0.60%. This gives a harder rail than that manufactured under commercial specifications, or demanded by most American railways, in which the carbon content is from 5 to 10 points lower. In the introduction of this additional carbon the Canadian Pacific Ry. has arranged to reduce the phosphorus in Bessemer steel to 0.085%, and in open-hearth to 0.06%, whereas the average American specification allows 0.10% phosphorus in Bessemer, and for open-hearth the standards are practically the same.†

This combination gives the Canadian Pacific rail greater hardness, and the same or greater toughness that is secured under the American specifications. The advantages are a better wearing rail and one which does not readily flatten at the joints under traffic. The reason for the difference in the carbon and phosphorus for open-hearth and Bessemer rails under the Canadian Pacific Ry. specifications is the inability of the acid Bessemer rail manufacturers in the United States to produce (at commercial prices) a low phosphorus rail. So that where phosphorus is 0.10%, the carbon should be kept below 0.50%; whereas with phosphorus 0.085%, the carbon should not exceed 0.63%, and should average about 0.58%.

It must be remembered, however, that the composition of steel in rails is not the only feature to be considered. In fact, the writer's experience has shown that some of the best rails in service are of the vilest composition. In other words, the heat treatment which steel receives during its manufacture into rails is of greater importance than the exact chemical composition.

*Eng. News, May 14, 1908, p. 530.

†For open-hearth steel rails, the American Railway Association's new standards limit the phosphorus to 0.04%. See reference already cited.

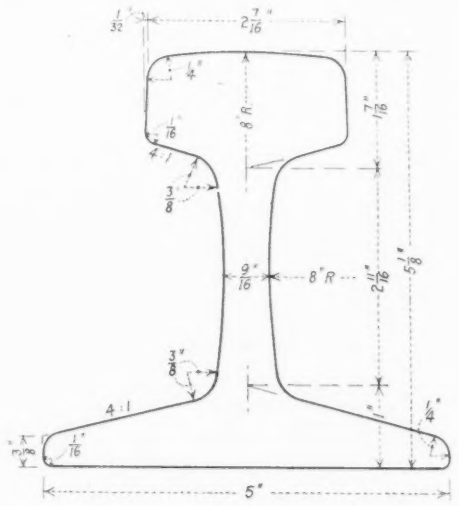
Specifications for 85-lb. Open-Hearth Steel Rails; Canadian Pacific Ry. (1908).

SECTION 1.—The section shall be in accordance with the plans, with an allowance in height of 1/64 in. under and 1/32 in. over. The fit of the fishing or "male" template shall be maintained perfect.

2. The weight of the rail shall be kept as near 85 lbs. per yd. as is practicable after complying with Section 1.

LENGTHS.—3. The standard length of rail shall be 33 ft. at a temperature of 60° F.; 10% of the entire order will be accepted in lengths of 27 ft. and 30 ft. All such short rails shall be painted green on both ends. A variation in length of ¼-in. longer or shorter will be allowed.

FINISH.—4. The rails must be free from all mechanical defects and flaws. They shall be sawed square



Vertical Inertia 29.492
Horizontal " 7.139

	Area Percentages	Cooling Percentages	Vertical Section	Horizontal Modulus
Head	36.77	1.965	10.425	
Web	22.21	3.081		
Base	41.02	2.875	12.84	2.855
Total	100.00	2.586		

The New 85-lb. Rail Section of the Canadian Pacific Ry.

at the ends, and the burrs made by the saws shall be carefully chipped and filed off, particularly under the head and on top of the flange.

5. The rails shall be smooth on the heads, straight in all directions, both surface and line, and without any twists, waves or kinks, particular attention being given to having the ends without kinks or drop. The hot-straightening shall be carefully done, so that gagging under the cold-press will be reduced to a minimum. The supports of the rail in the straightening press shall be not less than 42 ins. apart. Cold straightening shall be done so as not to injure the rails. "Lumpy" rails will not be accepted.

DRILLING.—6. Bolt holes 1 in. diameter shall be drilled through the web at 2 11/32 ins. from the bottom of the flange. The center of the first hole shall be 2½ ins. from the end of the rail, and the center of the second hole shall be 6½ ins. from that of the first hole. These holes must be drilled accurately in every respect; all burrs to be removed.

BRANDING.—7. The weight per yd. of rail, name of maker, month and year of manufacture, shall be rolled on the web of each rail in plain letters and figures, not less than ⅞-in. high and in sufficient relief for future identification. The heat numbers shall be stencilled three times on the web of each rail in distinct letters at least 9/16 in. high, placed on the opposite side from the brand marks. A letter shall be stamped on the heat number side of the web of each rail, clear of the angle bars, to indicate the portion of the ingot from which it was rolled.

COMPOSITION.—8. The rail in composition must be hard, sound and tough, showing fine, dense, grained metal, on fracture. The carbon shall average not less than 0.60%, within limits of 0.56% to 0.66%. The phosphorus shall not exceed 0.06%. The sulphur shall not exceed 0.055%. The silicon shall not exceed 0.18%, nor be less than 0.075%. The manganese shall not exceed 1.00%, nor be less than 0.80%. The sum of sulphur plus copper plus other injurious elements, not more than 0.075%.

HEAT TREATMENT.—9. The number of passes and speed of train shall be so regulated, that, on leaving the rolls at the final pass, the temperature of the rail

TABLE OF DIMENSIONS AND PROPORTIONS OF 85-LB. RAILS.

		Can. Pac. Ry.	A. S. C. E. * (Original.)	Pa. R.R.	Am. Ry. Assoc. † Thin head.	Am. Ry. Assoc. † Thick head.
1.	Height ... ins.	5 1/8	5 3/8	5 1/8	5 3/8	5 3/8
2.	Width of base ... "	5"	5 1/16*	4 5/8	4 5/8	4 1/2
3.	" of head, top ... "	2 7/8	2 5/8	2 5/8	....	2 1/16
4.	" of head, bottom ... "	2 1/8	2 1/16	2 1/16	2 1/16	2 1/2
5.	Side of head, slope ...	1/2	Vert.*	Vert.	1 to 1	3°
6.	Depth of head ... ins.	1 7/8	1 3/4	1 3/4	1 7/8	1 3/4
7.	" of web ... "	2 1/16	2 1/4	2 3/8	2 1/4	2 1/4
8.	" of base ... "	1	1 1/16*	1	1	1 1/16
9.	Thickness of web ... "	9/16	1/2	7/16	9/16	1/2
10.	" of edge of base ... "	3/8	.....*	.....	3/8	3/8
11.	Height to center of bolt hole ... "	2 3/8	.....	.....	.....	.....
12.	Radius, top of head ... "	8"	12"	10"	14"	12"
13.	" top corner ... "	1/4	1/2*	7/16	3/8	3/8
14.	" bottom corner ... "	1/4	1/2*	7/16	1/2	1/2
15.	" fillets ... "	1/2	1/4	1/4	3/8	1/2
16.	" corners of base ... "	(top, 1/4; bott. 1/8)	1/8	1/16	1/8	1/8
17.	" sides of web ... "	8°	12°	10°	14°	12°
18.	Edge of base ...	Round	Vert.	Vert.	Vert.	Vert.
19.	Fishing angle ...	4 to 1	13°	(head, 150; base, 130)	4 to 1	13
20.	Metal in head ... p. ct.	36.77	42*	42.2	37.5	39.45
21.	" in web ... "	22.21	21*	17.8	22.5	19.35
22.	" in base ... "	41.02	37*	40.0	40.0	41.20

*Note A.—The modifications recommended by the Rail Committee of the American Society of Civil Engineers in 1908 are as follows:

2. Width of base ½ in. less than height.
5. Sides of head vertical or nearly so.
8 and 10. Thickness of base to be increased.
13. Top corners of head not less than ⅜-in. radius with present M. C. B. wheel section.
14. Bottom corners of head of radius as small as practicable with colder conditions of rolling.
15. Fillets of as large radius as possible, for reinforcing purposes, consistent with the necessary bearing area under the head for the splice bars.
16. Corners of base of radius as small as practicable with colder conditions of rolling.
19. Fishing angles not less than 13° or more than 15°.
20 to 22. A fixed percentage for the entire series need not be adhered to (as in the original series). The percentage of metal in the base should preferably be equal to or slightly greater than that in the head.

†Note B.—The sections prepared by the American Railway Association vary by 10 lbs.; the figures given here for the 85-lb. sections are obtained by averaging from the 80-lb. and 90-lb. sections.

will not exceed that which requires a shrinkage allowance at the hot saw of 6¼ ins. for 33-ft. rails. No artificial means of cooling shall be used between the final pass and the hot saw.

TESTS.—10. While the heat is being cast, two test-ingots shall be made; the first from steel going into the first regular ingot, the other from metal taken from the last one. From each of these test-ingots a chemical analysis shall be made. These and all final analyses made by the works, relating to this contract, shall be furnished this railway company for its records.

DROP TESTS.—11. From each 50-ton heat three rail butts shall be tested. Each butt must not exceed 6 ft. in length, and must be taken from the top end of the first, middle and last ingots cast of each heat.

These butts shall be placed heads upwards on solid steel or iron supports, the distance apart of which in the clear, shall be 4 ft. Upon the butt shall be dropped a weight of 2,000 lbs. (whose striking face shall have a radius of not more than 5 ins.) falling freely from a clear height of 20 ft. Should two of the tests stand and show a deflection of less than 3¼ ins. under such test, this heat shall be accepted. If two fail it shall be rejected.

The anvil blocks shall weigh at least 20,000 lbs., and the supports shall be a part of, or firmly secured to the anvil.

Butts shall be tested to destruction as requested by the Inspector.

TREATMENT OF INGOTS, ETC.—12. After the ingots are cast, they shall be either constantly kept in an upright position until ready to be rolled, or else so maintained until the interior steel has had time to solidify.

13. No "bled" ingots or ingots from "chilled" heats shall be used in the manufacture of rails under this contract.

14. No ingots from badly-teemed heats shall be used.

CUTTING OF BLOOMS.—15. After cutting off or allowing for the "sand" or top-end of each ingot, at least 12 ins. more of seemingly solid steel shall be cut off that end of the bloom—a greater length than 12 ins. being preferred. If, after cutting such length, the steel does not look solid, the cutting shall continue until it does.

HEATING.—16. Care shall be taken to avoid overheating the steel, and, under no circumstances shall a "cinder" heat be allowed—that is, a heat high enough to cause the cinder to run off the steel as it is being drawn from the furnace. This does not apply to cinder which may be sticking to the under side of the steel when drawn from a horizontal furnace, or to the bottom of an ingot when draw from a soaking pit.

The specifications for 85-lb. rails of Bessemer steel are similar to the above, with the exception of the clauses relating to chemical composition and drop tests. These are as follows: (Ed. Eng. News.)

COMPOSITION.—8. The rail must be hard, sound and tough, showing fine, dense, grained metal in fracture. The carbon shall be within limits of 0.53% and 0.63%, and shall average between 0.57% and 0.59%. The phosphorus shall not exceed 0.085%. The sulphur shall not exceed 0.075%. The silicon shall not exceed 0.18%. The manganese shall be within limits of 0.80% and 1.00%. Copper and other injurious elements must not be more than traces.

DROP TESTS.—11. A rail-butt from every third heat shall be tested. The butt must not exceed 6 ft. in length, and must be taken from the top end of the first ingot.

All butts shall be placed heads upwards on solid steel or iron supports 4 ft. clear apart, and upon the butt shall be dropped a weight of 2,000 lbs. (whose striking face shall have a radius of not more than 5 ins.) falling freely from a clear height of 18 ft. Should the test fail or show a deflection of more than 3¼ ins. under such test, a second test shall be made. If it also fails, all rails made from that heat shall be rejected, but if the second test stands; then a third one shall be made, and, if this be successful, the rails of that heat shall be accepted.

Should the test from any heat fail, as above specified, similar tests shall be made from the preceding and succeeding heats, and if they fail as above specified, all rails from these heats shall be rejected.

A Table of Freight Rates on Coal, Iron and Portland Cement.

The accompanying table of freight rates has been compiled from information contained in a pamphlet entitled "Informal Presentation in the Matter of Discrimination Against the City and Port of Philadelphia in Railway Freight Rates for Transportation of Portland Cement." This pamphlet was prepared by Mr. Frank L. Neall and Mr. Ward W. Pierson to be presented before the Interstate Commerce Commission.

The rates have been arranged, for each commodity, according to the alphabetical order of the shipping points with a secondary arrangement, where more than one rate is given from the same point of shipment, according to the alphabetical order of the destinations. In cases where the means of transportation is not mentioned, it is understood to be by rail. It will be noted that there is a great disparity in the rates on the same commodity between different points when reduced to mills per ton mile.

FREIGHT RATES ON CEMENT, COAL AND IRON.

	Rate per ton.	Remarks.	Distance in miles.	Mills per ton-mile.
PORTLAND CEMENT.		2,000 lbs. = 1 ton.		
Lehigh District, Pa., to Atlantic City, N. J.	$2.00	via Philadelphia	150	13.3
Lehigh District, Pa., to Buffalo, N. Y.	1.90		357	5.3
Martins Creek, Pa., to Jersey City, N. J.	.80	via Trenton	114	7.0
Martin's Creek, Pa., to Philadelphia, Pa.	1.35		90	15.0
Martin's Creek, Pa., to Trenton, N. J.	1.30		57	22.8
Northampton, Pa., to Jersey City, N. J.	.80		95	8.4
Northampton, Pa., to Philadelphia, Pa.	1.35		74	18.2
Philadelphia, Pa., to Atlantic City, N. J.	2.40		60	40.0
Universal (Pittsburg), Pa., to New York City	2.40	Rate includes 60 cts. lighterage	441	5.4
Universal (Pittsburg), Pa., to Philadelphia, Pa.	2.00		351	5.7
IRON ORE.		2,240 lbs. = 1 ton		
Philadelphia, Pa., to Bethlehem, Pa.	.50	By rail	57	8.8
Philadelphia, Pa., to Birdsboro, Pa.	.60	By rail	49	12.2
Philadelphia, Pa., to Catasauqua, Pa.	.70	By rail	66	10.6
Philadelphia, Pa., to Harrisburg, Pa.	.70	By rail	112	6.3
Philadelphia, Pa., to Steelton, Pa.	.70	By rail	102	6.9
Philadelphia, Pa., to Pottstown, Pa.	.50	By rail	41	12.2
Superior (Duluth), Minn., to Buffalo, N. Y.	.70	By water	985	.07
Superior (Duluth), Minn., to Cleveland, Ohio	.70	By water	831	.08
PIG IRON.		2,240 lbs. = 1 ton		
Conshohocken, Pa., to Philadelphia, Pa.	.60		13½	44.4
Emaus, Pa., to Philadelphia, Pa.	.75		62	12.1
New York City to Wharton, N. J.	.90	Rate includes lighterage	78	11.5
Philadelphia, Pa., to Parryville, Pa.	.85		84	10.1
South Bethlehem, Pa., to Philadelphia, Pa.	.65		57	11.4
Wharton, N. J., to Philadelphia, Pa.	.80		140	5.7
SPIEGELEISEN.		2,240 lbs. = 1 ton.		
New York City to Rockaway, N. J.	1.15	Rate includes lighterage.	87	13.2
ORE.		2,240 lbs. = 1 ton.		
Mediterranean to Philadelphia—Baltimore	1.25	By water.	3,700	0.3
Philadelphia, Pa., to Chester, Pa.	.50	Imported ore; by rail.	18	27.8
COAL.		2,240 lbs. = 1 ton.		
Buffalo, N. Y., to Duluth, Minn.	.30	By water.	985	0.3
Hampton Roads, Va., to Charleston, S. C.	1.00	By water.	412	2.4
Hoboken, N. J., to Camden, Me.	.50	By water.	435	1.2
Lambert's Point to New London, Conn.	.60	By water.	395	1.5
New York City to Dartmouth, N. S.	.90	By water.	610	1.5
Perth Amboy, N. J., to Winter Point, Me.	.70	By water.	435	1.6
Philadelphia, Pa., to Boston, Mass.	.60	By water.	725	1.3
Philadelphia, Pa., to Halifax, N. S.	.90	By water.	725	1.2
Philadelphia, Pa., to Havana, Cuba	1.10	By water.	1,140	1.0
Philadelphia, Pa., to St. Johns, N. B.	.85	By water.	665	1.3
Philadelphia, Pa., to Savona, Italy	1.53	By water.	4,300	0.4
Philadelphia, Pa., to Tampico, Mex.	1.35	By water.	1,954	0.7
Port Reading, N. J., to Bangor, Me.	.50	By water.	410	1.2

The Strength and Absorption of Brick, and a Comparison between Different Methods of Determining Absorption.

Some interesting facts about brick were given by Mr. James E. Howard, Testing Engineer of the laboratory at Watertown Arsenal, Mass., in two papers read before the convention of the National Brick Manufacturers' Association at Rochester, N. Y., on Feb. 5, 1909.

The great strength which brick may reach was shown* by a short table of the greatest crushing strengths observed in half a dozen different materials: steel, glass, stone, etc. The table shows single high results, of course, and for that reason may mislead if its meaning is not carefully noted. For example, mild steel will develop approximately the strength (flow-point strength) quoted in every case, while brick reached the figure of 38,446 lbs. per sq. in. only in one rare case and ordinarily will fall far below this point. More common values for brick will be found in Table III., exhibiting a range from less than 2,000 to more than 25,000 lbs. per sq. in. However, Mr. Howard remarks that brick, more than most other materials, is very largely under control of the maker, as to its properties:

> Greater or less strength may be imparted, the density and elastic properties changed at will, all within limits of course, while as to artistic results through modifications in color and texture of surface, brick pre-eminently occupies a unique position. • • •
>
> It is recognized that the possession of great strength is not always required, perhaps in only few cases is it imperatively needed, some of the other features previously alluded to exerting a dominating influence in the use of the material.

In explanation of Table I., he states that the figures given represent the highest strengths found in 28 yrs. of testing at the Watertown Arsenal laboratory.

The figure given for mild steel refers to the load producing continuous flow without change of pressure. The tile which showed a strength exceeding 60,000 lbs. per sq. in. was 6 ins. square by 0.58-in. thick and was tested on edge. At 213,200 lbs. total load it burst suddenly into many fragments. The high-strength specimens of plate-glass had the same type of failure, as did also some of the stones. The first value given for Portland cement was obtained with a

*In a paper entitled "A Few Notes on Brick and Other Strong Materials of Construction."

sample of mortar confined in a steel cylinder and subjected to a pressure of 15,000 lbs. per sq. in. throughout its setting period. For ordinary setting, the figure of 9,000 lbs. per sq. in. is a high value.

TABLE I.—MAXIMUM CRUSHING STRENGTHS OF DIFFERENT MATERIALS, IN LBS. PER SQ. IN.

Mild steel	85,000
Glass, rough plate	51,700
	77,700
polished plate	45,000
	84,000
Tiles (American Encaustic Co.)	61,264
Granite (Salisbury, N. C.)	51,990
Granular quartz (Swanton, Vt.)	50,848
Marble (Friedman, Ariz.)	more than 50,000
Shale brick (St. Louis, Mo.)	38,446
Portland cement, set under high pressure	21,000
set without initial pressure	9,000

In a second paper* Mr. Howard discussed the indefiniteness of the term "absorption," showing that the ordinary absorption value is far below the real percentage of voids in the brick. Table II. herewith gives an abstract of his figures on this point, and the following extracts from the paper explain the matter.

For a number of years past it has been customary at Watertown in reporting tests of brick to state the amount of absorption both by volume and by weight, the period of immersion being one week. The difference in specific gravity of water and of burnt clay is such that a statement of the absorption taken by weight does not adequately express the actual voids which are in the brick; therefore figures which state the absorption taken by volume are given the preference.

It has been realized, however, that simple immersion of the brick even for a protracted period of time is not calculated to yield entirely satisfactory results, the absorption in most cases being underrated, although the results approach more closely to the truth in the case of salmon than in cases of harder-burned and denser brick. More water will be taken up by most brick, at the end of a week's immersion, if they are then boiled for a few hours, but even this treatment does not always result in the complete saturation of the material. Taking the specific gravity of the ground brick as a basis of comparison, the true voids are greater than indicated by the method of immersion followed by boiling, excepting the case of very porous and underburned material as previously mentioned. In hard and light hard building brick, and particularly in paving brick, it is impracticable to get the water into all of the interior voids and this results in accrediting the material with a lesser volume of voids than actually exist. Since the method of determining the voids by comparison of the specific gravity of the ground material with the weight per cubic foot of the intact brick shows higher absorption values than shown by other methods, this perforce is regarded as the more satisfactory one, for obviously it is not to be expected that any method will show more voids than actually exist.

* * * The specific gravities of the ground material were determined by the use of a Schumann volumeter, in which the volume of the ground material is indicated by the displacement of an equivalent volume of benzine in the flask. * * * The results [shown in Table II.] are taken to mean that current methods can hardly be accepted as reliably indicating the real values in absorption tests.

According to these figures the absorption is generally underrated in amounts from say 2 to 8%, with occasional examples reaching as high as 12 to 15%. There are paving brick in the table which would be reported as showing less than 1% absorption when taken by weight, but which according to the method of basing the voids upon the specific gravity of the material would have an absorption when taken by volume of more than 15%. Results such as these would indicate that the exterior portions of the brick were nearly impervious to water and masked interior voids.

Table III. shows the compressive strengths and moduli of elasticity of a number of brick, together with their weights and absorption.

The highest values of three of these features are found in the same brick in conjunction with the lowest values for absorption. A hard-burned brick of uniform structure will have a low absorption but will be a heavy brick, have a high compressive strength, and be comparatively very rigid, that is, possessing a high modulus of elasticity. On the other hand, high values for absorption are associated with low compressive strength, low modulus of elasticity, and, of course, lightness in weight.

*"Some Absorption Tests of Brick."

TABLE II.—VALUES OF ABSORPTION OF BRICK AS FOUND BY DIFFERENT METHODS.

Maker.	Kind.	Absorption after immersion one week. By weight.	Absorption after immersion one week. By volume.	Absorption after immersion 1 week and boiling one hour. By volume.	Computed value for absorption, based on sp. gr. of material and actual weight of brick. By volume.
		%	%	%	%
Illinois Brick Co.	Common	6.7	12.1	16.4	28.8
Hydraulic Press Brick Co.	Face	11.1	21.3	24.6	25.8
Hydraulic Press Brick Co.	Face	7.3	14.3	17.7	22.2
Hydraulic Press Brick Co.	Face	6.1	12.7	15.0	17.8
Hydraulic Press Brick Co.	Face	5.8	12.0	15.5	18.4
Coffeyville Vitrified Brick & Tile Co.	Face	19.9	27.5	30.	34.1
Coffeyville Vitrified Brick & Tile Co.	Face	14.2	25.6	27.5	32.5
Coffeyville Vitrified Brick & Tile Co.	Paver	9.3	12.9	21.2	28.6
Coffeyville Vitrified Brick & Tile Co.	Paver	.8	1.9	3.7	11.1
Coffeyville Vitrified Brick & Tile Co.	Paver	.6	1.3	3.9	11.7
Canton Pressed Brick Co.	Face	6.3	13.3	15.8	19.2
Canton Pressed Brick Co.	Face	6.4	13.8	16.8	20.2
Barr Clay Co.	Paver	.8	1.7	2.3	14.7
Barr Clay Co.	Paver	.8	1.9	4.5	15.1
Fernwood Lumber Co.	Common	12.7	20.4	28.2	33.8
Townsend Brick & Contracting Co.	Paver	3.5	7.1	10.3	17.1
Townsend Brick & Contracting Co.	Paver	3.7	8.2	11.3	19.6
Townsend Brick & Contracting Co.	Paver	3.7	8.0	10.6	19.5
Shawmut Mining Co.	Paver	2.7	6.0	8.9	17.3
Tuna Valley Pressed Brick Co.	Face	9.4	19.2	21.4	24.3
Tuna Valley Pressed Brick Co.	Face	5.8	13.3	16.9	19.1
Jewettville Pressed & Paving Brick Co.	Face	3.9	8.7	10.4	16.3
Jewettville Pressed & Paving Brick Co.	Face	2.6	5.9	7.6	14.4
Texarkana Brick Co.	Face	7.5	15.5	17.9	19.7
Texarkana Brick Co.	Face	8.5	17.4	19.1	21.7
Texarkana Brick Co.	Face	16.9	30.1	31.7	31.8
Denny-Renton Clay & Coal Co.	Face	7.2	15.	18.1	20.8
Denny-Renton Clay & Coal Co.	Face	13.2	23.7	27.3	30.
Denny-Renton Clay & Coal Co.	Face	14.0	24.7	27.8	30.3
Denny-Renton Clay & Coal Co.	Face	1.8	4.1	5.7	12.3
Western Brick Co.	Common	2.	4.6	6.6	14.8
New York Brick & Paving Co.	Paver	.3	.7	1.4	16.5
New York Brick & Paving Co.	Paver	.9	2.2	3.5	9.3
New York Brick & Paving Co.	Paver	.1	.3	.9	15.2
New England Brick Co.	Common	1.9	4.4	5.9	12.0
Simons Brick Co.	Common	10.4	19.2	25.2	30.9
Sand Lime	Face	11.5	22.4	22.9	24.4

TABLE III.—COMPARATIVE TABLE OF WEIGHT, ABSORPTION, STRENGTH AND ELASTICITY OF VARIOUS BRICKS.

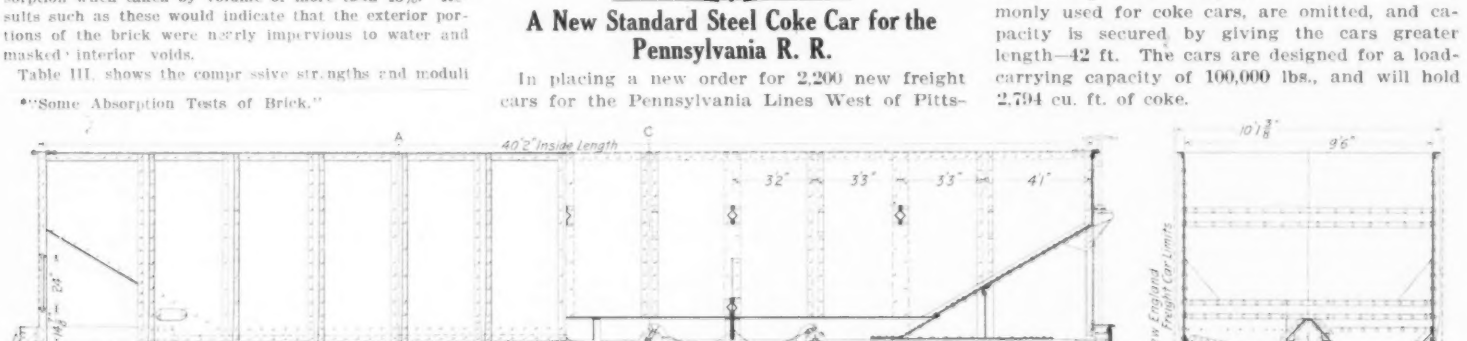
Maker.	Kind.	Weight, lbs. per cu. ft.	Specific gravity of ground material.	Absorption, by volume.	Compressive strength, lbs. per sq. in.	Modulus of elasticity, lbs. per sq. in.
Hydraulic Press Brick Co.	Face	120.3	2.60	24.6	4,268	1,031,000
Hydraulic Press Brick Co.	Face	123.3	2.55	17.7	8,536	1,786,000
Hydraulic Press Brick Co.	Face	120.2	2.52	15.	13,506	2,778,000
Hydraulic Press Brick Co.	Face	120.3	2.54	15.5	13,470	2,439,000
Coffeyville Vitrified Brick & Tile Co.	Face	111.5	2.71	30.	2,253	833,300*
Coffeyville Vitrified Brick & Tile Co.	Face	112.4	2.67	27.5	6,046	2,632,000
Coffeyville Vitrified Brick & Tile Co.	Paver	119.8	2.69	21.2	8,828	6,203,000
Coffeyville Vitrified Brick & Tile Co.	Paver	144.9	2.63	3.9	18,745	6,667,000
Canton Pressed Brick Co.	Face	132.	2.62	15.8	7,816	1,852,000
Canton Pressed Brick Co.	Face	135.4	2.72	16.8	11,314	3,804,000†
Townsend Brick & Contracting Co.	Paver	139.6	2.70	10.3	15,385	7,692,000
Tuna Valley Pressed Brick Co.	Face	127.6	2.76	21.4	7,820	2,494,000
Tuna Valley Pressed Brick Co.	Face	135.8	2.69	16.9	14,148	5,556,000‡
Jewettville Pressed & Paving Brick Co.	Face	139.9	2.68	10.4	23,760	6,250,000
Jewettville Pressed & Paving Brick Co.	Face	142.6	2.67	7.6	25,302	7,692,000
Texarkana Brick Co.	Face	129.8	2.59	17.9	8,889	3,448,000
Texarkana Brick Co.	Face	127.5	2.61	19.1	5,164	1,563,000
Texarkana Brick Co.	Face	111.1	2.61	31.7	1,754	342,500§

Absorption after one week's immersion followed by boiling 4 hrs. Modulus of elasticity measured between loads of 1,000 and 3,000 lbs. per sq. in., with the following exceptions:
*Modulus of elasticity taken between loads of 1,000-2,000.
†Modulus of elasticity taken between loads of 1,500-3,500.
‡Modulus of elasticity taken between loads of 1,500-3,500.
§Modulus of elasticity taken between loads of 500-1,000.

A New Standard Steel Coke Car for the Pennsylvania R. R.

In placing a new order for 2,200 new freight cars for the Pennsylvania Lines West of Pittsburg, it has been specified that 1,000 cars shall be all-steel cars for carrying coke, of a new design, having greater capacity than any coke cars hitherto built. Drawings of these cars are shown herewith.

The car has four hoppers, giving eight openings in the bottom of the car, permitting quick dumping without hand clearing. The total area of opening in the bottom of the car, with all doors open, is 84 sq. ft. The racks at the top of the car, which have been commonly used for coke cars, are omitted, and capacity is secured by giving the cars greater length—42 ft. The cars are designed for a load-carrying capacity of 100,000 lbs., and will hold 2,794 cu. ft. of coke.



42-FT. STEEL COKE CAR OF 100,000 LBS. CAPACITY; PENNSYLVANIA R. R. LINES WEST OF PITTSBURG.

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The trend of teaching methods in most American technical schools admittedly has been fatal to those close and inspiring personal relations between teachers and students which were possible in the engineering schools of a generation ago. This tendency seems to have been generally regarded as a mere passing of "the good old days," to be lamented by old men on sentimental grounds, perhaps, but to be accepted by the rising generation as a necessary sequence of larger schools, larger classes and actual progress in technical instruction. Lectures to massed students have been widely accepted, until recently, as a necessary feature of the new order of things educational. Yet excessive dependence on lectures and lecture notes has been decried* as leading the average student to a disregard of detail and of accuracy. However, until recently, little protest has been made against lectures to large classes as the thief of delightful and inspiriting friendships, for such relations were not believed to be necessary in the education of an engineer. Now insistent voices are demanding a return of the old relations, not on grounds of sentiment, but for true economy of effort, time and money. Of course, all lecture methods cannot be held wholly responsible for the loss of a teacher's personal oversight of a boy's work in those schools where such a need is now being felt most keenly. But the wide extension of lecture methods will probably be held as the greatest single factor in present inadequate or uneconomical provisions for large classes in engineering subjects.

The experience of many teachers in various parts of the country emphasizes the need of personal oversight and of individual instruction, not only for good results in training the best type of engineers but also for true economy in the teaching process. The results of the experiment by Dean Raymond, of the Iowa State University, shown elsewhere in this issue, will be thoughtfully considered by teachers of engineering subjects throughout the country.

Coincident with the publication of the account of Dean Raymond's work, there comes to hand some significant expressions by Prof. A. A. Noyes, in his annual report as Acting President of the Massachusetts Institute of Technology. In one of these passages Prof. Noyes briefly alludes to the plan of individual conferences upon the progress of students' work in certain subjects and their insight into the principles. In remarking on the success of the plan and its extension from first-year English and mathematics to second-year physics, Prof. Noyes especially emphasizes the need of close personal relations between teachers and students. Of present methods of giving needed instruction he has this to say:

> The establishment of close personal relations between instructors and students is a matter of prime importance to the success of the work of instruction. The plan of individual conferences, just referred to, supplements the recitation system in a most valuable way. I believe, however, that there exists in some of our important first and second-year subjects a further opportunity for accomplishing much in this direction through a different organization of the work. Instead of having, as is now done in some cases, a group of instructors teach in common in the laboratory or drawing-room a whole class of from three to four hundred students, while another group carries on the class-room work in the same subject, and perhaps a third group corrects the written work submitted, much better results would, I am sure, be obtained by placing each instructor in full charge of a limited number of students, say 60 or 80, and having him, with the aid of an assistant when necessary, carry on with those students all the different sides of the work in the subject in question (except the course of experimental lectures, which it is especially uneconomical to repeat). He would thus not only get much more closely acquainted with his students and come to understand their individual difficulties, but he would feel a personal responsibility and pride in the success of those intrusted to him. He has, moreover, a greater variety of work, and avoids the monotony of an undue number of repetitions of the same exercise with a large number of sections.
>
> The present method of giving such instruction to large classes has grown up in the larger colleges as a result of an assumed need of economy in this direction; for there is some economy of effort in the division of labor between the different sides of a teacher's work, and there is a large economy in the average salary paid when one professor is employed to supervise and to give the lectures, and inexperienced or otherwise inefficient instructors and assistants are engaged to do the real teaching. From an educational point of view, however, the method is unsatisfactory; and, until it is abandoned, the problem of handling large classes will not be adequately solved, and large colleges will be at a disadvantage in comparison with small ones. Moreover, though the other plan of individual responsibility does involve additional expense, the amount required is not inordinate; for the main work of instruction might well be done by men of intermediate grades receiving (according to their length of service) from $1,000 to $1,800 a year; and it would, I believe, be better to curtail expenditure in almost any other direction than in this one, which is so essential to the efficiency of the teaching of our fundamental subjects.

A dozen years ago, more or less, the city of Minneapolis seemed to be on the point of installing a water-purification plant. For reasons which we are quite unable to state, the city is still drinking water which, according to all modern standards, is certainly not above suspicion. The typhoid death rate per 100,000 for the period 1901-05 averaged 37.8, and for 1906 the rate was 32.9. These figures do not compare at all well with the corresponding ones for St. Paul, which were 12.5 and 21.1 respectively. Minneapolis takes its water-supply from the Mississippi River straight, while St. Paul has the benefit of water drawn from a chain of lakes which are presumably comparatively free from pollution, and also from artesian wells.

We understand that a movement is now on foot in Minneapolis to have the whole water-supply question investigated by a citizens' committee of 21, made up for the most part by nominations of one member each by the various commercial and other organizations of Minneapolis, including the Hennepin County Medical Association and the Woman's Club of Minneapolis. Inasmuch as the resolution of the City Council providing for the appointment of this commission specifically states that the commission "shall not be authorized to incur any expense on behalf of the city," it seems a little uncertain what it was expected that the committee could accomplish. Lack of funds, however, need not spell failure, since the committee may do excellent service by merely reviewing the delays in securing pure water and the dangers incident to their continuance, at the same time emphatically urging the city authorities to either follow the expert advice already secured, or, if they cannot agree to do that, then to recall the experts or appoint new ones to report on the problem.

Minneapolis is altogether too large and important a city to postpone longer the securing of a pure water-supply. It is high time for it to fall in line with Lawrence, Albany, Providence, Philadelphia, Pittsburg, Cincinnati, New Orleans, Indianapolis, and many lesser cities in establishing an adequate water-purification plant, or else copy those cities which have introduced supplies that for the present may be considered satisfactory without purification. If it adopts the latter alternative it should bear in mind that the whole trend of the day is toward purification of all water-supplies from surface sources.

While we do not mean to throw any doubt upon the evidently high character of the St. Paul water-supply, yet it seems pertinent to inquire why its typhoid rate for 1906 was 21.1 per 100,000, as compared with a maximum of 13.7 during the previous five years, and less than 11 in 1903 and again in 1905. If the proposed legislation giving the Minnesota State Board of Health large measures of control over the water-supplies of the state, as outlined editorially in our issue of Feb. 11, goes into effect, as we hope it will, such erratic movements in the typhoid rate of any Minnesota city seem quite certain to be made the subject of careful investigation—if indeed they are not already looked into by the State Board of Health on the strength of existing legislation. What we are saying here in regard to St. Paul typhoid, however, should be considered as suggestive rather than condemnatory, as it may be that the local board of health has typhoid matters well in hand, and it may also be that later statistics show a return to the normal typhoid rate of St. Paul, which for an American city is remarkably low. Perhaps, too, later typhoid figures for Minneapolis cast less doubt upon its water-supply, but however that may be, we think there is no question but what either water purification or a new water-supply is needed by Minneapolis, and that at once.

A British Professor's "Research" in Steam Boiler Design.

We are sometimes tempted to make iconoclastic remarks on the subject of what may be termed, for what of a better name, "professorial" engineering; but we hasten to make an apology for the use of this term, to the many engineers of real ability, large practical experience and sound common sense, who are engaged in the work of instruction in our engineering schools.

And having made this apology, we may proceed to say that technical literature is to-day, as it has been for a quarter century past, continually encumbered with abstract "researches" and investigations which will never be of any practical usefulness to anybody. If the truth concerning these published "researches" were known, we suspect it would be found that nobody but the distinguished author and a few distinguished colleagues engaged in a similar sort of work, ever takes the time or the trouble to study them.

We are tempted to these iconoclastic remarks by noticing in our London contemporary, "Engineering," of Feb. 12, a paper entitled "Heat Transmission in Steam Boilers," by "John T. Nicolson, D. Sc., M. Inst. C. E. (Hon. Mem. J. Inst. E), Professor of Mechanical Engineering in the University of Manchester." The paper is so long that it is run as a serial in our contemporary, and the concluding section in the issue before us occupies six solid pages, which bristle with mathematical formulas.

A combination of curiosity and some interest in the special subject led us to examine this paper. We find that the result of the author's laborious research has been the development of a formula,

*"The Abuse of the Lecture Method of Teaching Engineering Subjects," Engineering News, Aug. 17, 1905.

and for those of our readers who have to wrestle with steam-boiler propositions we venture to record that formula in full. It is as follows:

The general formula for the heat transference from a gas flowing along a flue is accordingly

$$Q = \left[\frac{\phi}{200} + \frac{1}{40}\sqrt{\phi}\left(1 + \frac{1}{m_1}\right)\rho_1 u_1\right](T - \theta).$$

where

Q = B.T.U transferred per hr. per sq. ft. of flue surface.
T = temperature of gas flowing along the flue, deg. Fahr.
θ = temperature of metal wall of flue, deg. Fahr.
ϕ = ½ $(T + \theta)$ = mean film temperature, deg. Fahr.
ρ_1 = density of gas, lbs. per cu. ft.
u_1 = speed of gas in ft. per sec.
w_1 = lbs. of gas flowing per sec.
a_1 = area of flue in sq. ins.
c_1 = perimeter of flue in ins.
$m_1 = a_1/c_1$ hydraulic mean depth of flue or pipe.

The author calls this his "new formula," and he then proceeds to compare this formula with one recommended by Rankine, which appears to us considerably more modest and which is as follows:

$$Q = \frac{(T - t)^2}{160 \text{ to } 200} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where

Q = heat transmitted per sq. ft. per hr. (B.T.U.)
T = average gas temperature (deg. Fahr.).
t = water or steam temperature (deg. Fahr.).

The author says that "Rankine's formula has been very generally used in heat transmission calculations for steam boilers," but we confess to an inward query as to what percentage of the steam boilers in actual use were ever designed by the aid of this Rankine formula.

The author, however, does not stop at this point. He is not contented with having bestowed upon the profession a boon in the shape of a seven-term formula in place of a two-term; but he goes on, after several columns of invidious comparison between his "New formula" and the old, to explain "the import upon boiler practice of the results obtained."

This is interesting. We always like to see, after an investigator has used reams of paper and bottles of ink in chasing x's and y's and z's and a choice collection of Greek letters and mathematical signs through a large number of contortions—we always like to see, we say, a final conclusion in which he gets down to earth and tells the reader what practical lessons he is to derive as the result of all that has gone before. In order to do the author strict justice, we quote this practical conclusion verbatim:

In the first place, since the amount of heat that can be transmitted for a given temperature-difference is almost directly proportional to the speed of the gases, a reduction of area of the heating surface in steam boilers—to one-half, one-quarter, or even one-tenth of what is now usual—can be made without the chimney temperatures being raised or the efficiency lowered to any material extent. Or, otherwise, if the surface be kept the same, but the cross-sectional area through the flues be reduced, in order to obtain the necessary high gas speed, a very much lower chimney temperature and correspondingly higher efficiency can be secured than is now available.

Accordingly, draughts of 10 ins. or 20 ins. of water-gage, induced by fans, should always be employed for really economical working.

There is more; but the above leaves us gasping, and we think it will be enough. We may remind our readers who may be unfamiliar with boiler practice, that with ordinarily good stationary boilers a draft of ¾-in. to 1-in. of water is about the maximum used, and that even with the highest forced draft practice on locomotives, where some 20% or 30% of the coal fired is often carried through the stack and distributed impartially over the right of way, the draft pressure seldom exceeds 5 to 8 ins.

We have no doubt that the distinguished author of the paper on which we have taken the liberty to comment has good intentions; but the cataclysm which he would produce in any place where combustion should be carried on with such a draft as he proposes, would resemble the locality which is said to be paved with similar good intentions. No boiler burning actual fuel and doing actual practical work was ever made or operated under any such conditions as are here gravely recommended at the behest of a mathematical formula. It all seems to us a fearful and wonderful example of the utter folly of "research" carried on without the aid of that definite, practical, hardheaded common sense which is the prime requisite to sound engineering.

Recent Developments in Rail Design and a Comparison of Rail Sections.

The question of rail section design has been a live issue for several years past, after a period of quiescence following the very general adoption of the sections recommended by a committee of the American Society of Civil Engineers in 1893. It will be useful and interesting therefore to review some of the recent development, especially in connection with the design of the new rail section of the Canadian Pacific Ry., which is described elsewhere in this issue. During the past few years there have been complaints from railways as to unsatisfactory experience with the heavier rails of the so-called Am. Soc. C. E. sections, while manufacturers have claimed that they could not make first-class rails in the heavier weights of these sections, owing especially (among other details) to the thin edges of the base. The Society therefore appointed a new committee to consider this matter, and in 1908 it made a report recommending certain modifications from the original designs, but not presenting definite sections. (Engineering News, Jan. 23, 1908.)

The recommendations of the above committee have been approved by the American Railway Association and the American Railway Engineering and Maintenance of Way Association. The former of these associations has also promulgated proposed standard rail sections, but rather unfortunately presented two series of designs, each consisting of five sections ranging from 60 lbs. to 100 lbs. per yd., inclusive (Engineering News, May 14, 1908). One series was designed to meet the requirements for a rail with a thin head and a high moment of inertia. The other was to meet the requirements for a rail with a narrow and deep head, and with the moment of inertia considered as a secondary matter. It may be said that the advocates of the former type are in a decided majority.

Certain important railways have always continued to use rails of their own design, and while the questions of improving the Am. Soc. C. E. sections or designing new standard sections have been under consideration by railway and engineering societies, some other railways have introduced special sections of their own. Several of these have been described in our columns. These modern sections, of course, are designed on scientific principles, and are not to be compared with the heterogeneous sections which were in use before the American Society of Civil Engineers first began its work of preparing a logical design for a standard rail section. It is also to be borne in mind that the universal adoption of any one type of section is not to be expected.

The adoption of the original Am. Soc. C. E. sections was so general, however, that it seems as though it should be quite practicable to improve these in such a way as to meet with an equal degree of acceptation by the railways. In fact the modifications recommended in 1908 by the Rail Committee of the Society deal with most of the features which have been a source of complaint. It appears, therefore, somewhat unfortunate that there is a certain tendency at the present time to multiply individual rail sections. With this in view it may be of interest to review the design of the new 85-lb. rail section of the Canadian Pacific Ry., which has been mentioned above and which is illustrated elsewhere.

Taking first the general form of this section, it may be said that it represents the thin-headed type, the depth of head (to intersection of fishing angles) being only 2 7/16 ins. The total height is somewhat low for a rail of this weight and type. This was adopted, however (as stated in the paper by Mr. Gutelius) in order to provide a certain flexibility on tracks where heaving occurs every winter and shimming must be done to keep the track in surface. Under such conditions it has been found that a heavy stiff rail is more liable to fracture than a lighter and more flexible rail.

The width of base is only ⅛-in. less than the height. The suggested modifications of the Am. Soc. C. E. sections recommend a base width ½-in. less than the height, but Mr. Gutelius does not consider this advisable on the point of stability. By interpolation, the 85-lb. rail of the American Railway Association's thin-head type would be 5⅜ ins. high and 4⅞ ins. wide.

In considering the form of the head of the Canadian Pacific rail, we find that as compared with other similar rails it is narrowed slightly at the top by giving the sides a small inward slope. This slope is permitted in the modifications suggested for the Am. Soc. C. E. section, which provide that the side may be vertical or with a slight inclination. In the original sections the sides were vertical. The slope is intended evidently to hold the wheel away from the top corner, the radius of which is quite sharp, ¼-in. This radius was preferred by several engineers at the time the Am. Soc. C. E. sections were designed (1893), but 5/16-in. was then adopted as a compromise between the sharp-corner and round-corner ideas. The present rail committee of the society, however, has recommended that this radius should be not less than ⅜-in. while the present M.C.B. wheel section is in use. The Pennsylvania R. R. has adopted 7/16-in.

The Canadian Pacific Ry. section goes to an extreme, however, in regard to the radius of the top of the head, which is only 8 ins. This is the sharpest radius in use in this country, although a 5¾-in. radius is adopted for the Sandberg 100-lb. rail which is used extensively in Europe. The Pennsylvania R. R. standard rail with 10-in. top radius has always been considered as a round-headed rail (especially with its 7/16-in. corner radius). The 12-in. radius of the Am. Soc. C. E. sections is very general. A 14-in. radius is used in the Dudley sections, which have been adopted by several large railway systems; it is adopted also in the American Railway Association sections. Mr. Gutelius informs us that the top radius was reduced to 8 ins. in the new section for the reason that it conforms more nearly to the section of rails that have been in the track for a number of years than does the 12-in. radius of new rails of the Am. Soc. C. E. type. It remains to be proved, however, whether it is wise to adopt for new rails the section to which old rails have been worn by long service.

The web of the Canadian Pacific Ry. rail is peculiar in having the sides curved to the unusually short radius of 8 ins., and united with the web and base by fillets of ⅜-in. radius. In other sections, the web has its sides either vertical or curved to a radius of from 10 to 14 ins., and has fillets of ¼-in. radius. The idea in curving the sides of the web is to give a better flow of the metal and better compacting during the process of rolling. Mr. Gutelius informs us that his idea in adopting the unusually short 8-in. radius was to give a better bearing under the head, and thus strengthen what his road had considered to be a weak point in the Am. Soc. C. E. section. This had been taken into consideration, however, by the new rail committee, whose recommendations (1908) included the giving to the fillets as large a radius as possible for the purpose of reinforcement, consistent with providing the necessary bearing surface for the splice bars.

In the new Canadian Pacific rail the thickness of the base is increased, and the shape of the edge of the base is peculiar in having a round (¼-in.) top corner and a sharp (1/16-in.) bottom corner. In most sections the corners are of 1/16-in. radius, and between them the edge of the base is vertical. This is provided in the Am. Soc. C. E. sections, and the Rail Committee has recommended no specific change, but states that the corners should be as sharp as is practicable with the colder conditions of rolling now specified. Mr. Gutelius states that the strengthening of the flange appears to have eliminated flange-breaks entirely in rails laid in the track. The larger top corner radius for the base or flange of the Canadian Pacific Ry. rail is in accordance with some European rail sections and American tee-girder rails. The unsymmetrical arrangement has a somewhat peculiar appearance on the drawing, but the round top corner no doubt allows of a better flow of metal as the rail passes through the rolls. The proper filling out and rolling of these comparatively thin edges has always been a difficulty in the rolling of large sections of T-

rails at the low temperatures which are necessary to produce rails of good quality.

Coming now to the distribution of metal in the head, web and base of the new rail, we find a curious feature in comparison with the original Am. Soc. C. E. section. The proportions of metal in the head and base of the two rails are in fact reversed. This is shown by the accompanying table, in which we have compared the distribution in several 85-lb. rail sections. The rail committee of the American Society of Civil Engineers, however, recommended in 1908 that for rails heavier than 60 lbs. per yd., the percentage of metal in the base should be equal to or slightly greater than that in the head. Also, that the proportions might vary in sections of different weights, although in the original sections there was a uniform distribution for the entire series. The Canadian Pacific Ry. rail, therefore, follows the first of these recommendations. It will be seen by the table, also, that the same principle is embodied in the section of the Pennsylvania R. R. and in one of the two types of sections promulgated by the American Railway Association. Exact comparisons cannot be made with these latter, as the sections vary by 10 lbs., but we have given the average between the 80-lb. and 90-lb. sections.

PROPORTIONS OF METAL IN 85-LB. RAILS: TOTAL, 100 PER CENT.

	Head.	Web.	Base.
Can. Pacific Ry.	36.77	22.21	41.02
Am. Soc. C. E. (original).	42.00	21.00	37.00
Pennsylvania Ry.	42.20	17.80	40.00
Dudley type.	42.20	21.10	36.70
West. Pacific Ry.	45.70	18.00	36.30
Gt. Nor. Ry.	42.00	22.00	36.00
Am. Ry. Assoc. *(thin head).	37.50	22.50	40.00
Am. Ry. Assoc. *(thick head).	39.45	19.35	41.20

*Medium between 80-lb. and 90-lb. sections.

In the Pennsylvania Ry. section, the proportion of metal in the base is increased at the expense of the web. Of all the rails, that of the Western Pacific Ry. has the highest proportion of metal in the head, while the proportions in the web and base are low. In fact, the proportion in the web is almost the minimum of all the sections. The Great Northern Ry. rail, though of very peculiar section, has almost the same proportions as the original Am. Soc. C. E. sections. The Pennsylvania section was illustrated in our issue of April 16, 1908; the Western Pacific and Great Northern sections in our issue of Oct. 15, 1908.

As a result of this review we arrive at the conclusion that the Am. Soc. C. E. sections modified in accordance with the recommendations made a year ago by the Rail Committee of that society, should meet all the reasonable objections that have been made both by the railway and by the manufacturers. The multiplication of new and individual sections appears, therefore, to be inadvisable. Furthermore, these modified heavy Am. Soc. C. E. sections should meet with as universal approval and adoption as were accorded the original sections at a time when the sections of medium weight were those most generally used.

LETTERS TO THE EDITOR.

More Evidence of the Longevity of Creosoted Piles.

Sir: In line with your article in the issue of Jan. 7, p. 23, on the Galveston bridge and "Resident Engineer's" letter on the Cartagena, Columbia, S. A., wharf in the issue of Jan. 21, p. 73, the record of some creosoted piles used on the gulf coast between Mobile and New Orleans may be of interest.

The formation along this coast is such that pile foundations are necessary for all bridges. The bridges on the New Orleans & Mobile Division of the Louisville & Nashville R. R. were built (or possibly, rebuilt) about 1875. They were truss spans supported on pile piers direct (no masonry used) and had pile trestle approaches. All piles were, I think, creosoted at the West Pascagoula works and up to 1904 not a pile had been removed or had shown any serious signs of decay.

In 1904 and 1905 it became necessary to replace the truss spans of the East and West Pascagoula rivers and the Rigolets and Chef Menteur bridges, with stronger bridges in order to take care of heavier rolling stock. Through or deck girders were decided upon for the new bridges except for the draw spans, where through trusses were used. The grade line was kept as low as possible to allow the bottom of girders to clear extreme high tide. Examination of, and borings into, the piles showed many of them still to be in perfect condition so it was decided to utilize as many as possible of them as were perfectly sound in the new structure. Intermediate piers were driven and the old piers reinforced by additional piles, many of which had to be jetted in.

In the Chef Menteur bridge not a single pile was replaced on account of defects, and in the other three bridges the proportion was less than 10%. Of those rejected and replaced by new piles not a one had been damaged by teredo, nor had the outer ring penetrated by the creosote shown any signs of deterioration, nor was a single pile seriously decayed. The rejected piles showed an interior dry rot which indicated that they had not been perfectly sound when treated, probably having been doty to a slight extent. Piles which were checked or wind shaken at times of treatment were in a perfectly preserved state, the creosote having penetrated to the interior of the wood. As the new cut-off level was several feet lower than the old and below the extreme high tide level, there was opportunity for a thorough examination of the condition of each pile. Every pile showing the least sign of decay was replaced, even though its strength had not yet become impaired. All other piles appeared to be as sound as the day they were driven, some 30 years before. The bridges mentioned are all across tidal streams.

Yours truly, W. G. Arn,
Ass't Engr., Illinois Central R. R.

Corinth, Miss., March 1, 1909.

Report of the Coroner's Jury on the Chicago Tunnel Crib Disaster.

Sir: After reading the verdict in the above case, as reported in your issue of Feb. 25, I feel (as foreman of that jury) that some of the circumstances should be more fully explained. Therefore I will say that this case was a particularly difficult one so far as the state laws and city ordinances were concerned, and for this reason the jury were advised by competent attorneys. A careful examination of the law showed (1) that no city ordinance was violated at the crib; (2) that as a matter of fact no city law or regulations applied thereto; (3) that while the city had power to legislate a distance into the lake beyond the location of the intermediate crib, it had never taken advantage of such power, therefore the intermediate crib was entirely outside the jurisdiction of the city ordinances.

The best evidence showed that the contractor, George W. Jackson, Incorporated, had obtained every necessary permit for the work carried on at 73d St. and Bond Ave., at which point the same tunnel was being driven from another shaft (the shore shaft).

There is a state law which requires that no dynamite or other explosive shall be "stored" within 300 yds. of any "inhabited dwelling." The primary object of this crib, however, was not to furnish a place of residence, but for use in connection with the building of the tunnel. It was probably not a residence within the strict meaning of the law, although the preponderance of legal opinion was disposed to concede that it should be considered an inhabited dwelling. It appeared, however, that according to the intent and purpose of the law, no dynamite was stored. It was sent out to the crib only as required, and no supply larger than necessary was received at any time. Neither was it delivered earlier than the conditions of the work demanded, therefore there was no violation of the state law. Thus in view of the fact that there had been no violation of law, it was impossible for the jury to bring in any verdict other than the one rendered.

This was an unusual piece of work. It was an extremely large tunnel and the first one at this city to be driven under the lake in the rock, and for that reason, it was essential to use large quantities of dynamite. It was a hazardous yet necessary undertaking, and there was corresponding danger attendant.

It is true that the method of handling the dynamite was unsatisfactory and dangerous, but no more so than the general prevailing methods elsewhere, and the cause of the accident was probably due much more to ignorance than to carelessness.

Very truly yours,
A. Bement,
Consulting Engineer.

2114 Fisher Ave., Chicago, Ill., Feb. 27, 1909.

Panama Sea-Level Arguments.

Sir: I have been much interested in the able advocacy of the lock system for the Panama Canal in the last two issues of Engineering News. As these arguments are given "without prejudice or bias" it is natural to expect that a periodical of the high standing of the Engineering News would open its columns for a hearing to an advocate of the sea-level plan.

In the first place please let me state emphatically that I am a firm believer in the Panama Canal and as a resident of Colombia its successful completion will be to my pecuniary benefit. Further, I have nothing but undiluted praise for the Administration which has produced results of over twice the excavation anticipated three years ago by the most sanguine engineer, and under almost ideal health conditions and without a suspicion of graft.

I will quote from my paper in the January Bulletin of the American Institute of Mining Engineers.:

THE CHAGRES RIVER.

In the original sea-level plan, the Chagres was regarded as a menace, and it was proposed to restrain its floods behind a dam at Gamboa. The maximum flood of the Chagres, 79,000 cu. ft. per sec.,[11] is reached only once in years, and then for a few hours only.

If this flood entered a sea-level canal of 300 ft. width and went wholly towards a single outlet, it would, in some places, for a brief time, flow at the rate of 3.14 miles per hr. My experience in numerous trips on the Magdalena River, in Colombia, where the current frequently exceeds this speed for protracted periods, yet steamers are, nevertheless, constantly navigating over shoal bottoms and around sharp turns, and also in frequent journeys on the Atrato in time of flood, makes me feel that this condition would offer no real obstacle to navigation. The section I propose, of 300-ft. bottom-width of prism, would eliminate all possible objection on that score. The real point is, that such a body of water should not be allowed to rush into the canal in a concentrated mass, forming whirlpools, but should be let down on a stepped apron, a mile long, so that, even in the greatest flood, a depth of 2.5 ft. would bring all the water inoffensively down to the sea-level, 45 ft. below. The only trouble from the Chagres would be its bringing down of gravel,[12] and thus requiring occasional dredging opposite its mouth. The apron required could be so constructed as to hold some slack-water behind it; and a 6-ft. dam at a favorable location about a mile above would compel the current to quiet down below the gravel-carrying point. Power could be generated at the mouth of the Chagres for lighting part of the canal.

THE PACIFIC TIDE-LOCKS.

The original plan placed these locks at the shore, but that has been abandoned, and the first locks are to be at Miraflores, 5 miles inland, to which point a 500-ft. channel will be dug, permitting steamers to pass at full speed. The water in this 5-mile stretch will flow in and out with the tide. The majority of the Board was not entirely convinced of the necessity of tide-locks, or even of their possible usefulness, except for a few hours daily during spring tides, the gates to be left open and the water to flow in and out at will at all other times.[13]

Are tide-locks necessary at all? The extreme head in spring tides would be 10 ft. This, for 40 miles of canal, would mean, for a few moments at the turn of the tide, a head of 3 in. per mile. The Atrato River, in 244 miles, from Quibdo to its mouth, has a fall of over 150 ft., or more than 7 in. per mile, yet the average current is only 2.5 miles per hr.; and the mean current in time of high freshets, even at the upper end, near Quibdo, is only about 3 miles per hr.

The head from the Atlantic to the Pacific at Pacific low water would be the same as the head from the Pacific to the Atlantic at Pacific high water—namely, 10 ft. In either case, an amount of water would have to enter or leave the canal by hydrostatic action equal to the frustum of a prism whose base is that of the upper 10 ft. of the section of the canal, and whose length is 40 miles. This constitutes a total of 435,600,000 cu. ft. distributed over 6 hrs., or a flow of 72,600,000 cu. ft. per hr, which, for a total section of 14,400 sq. ft., would give a rate of 5,042 ft., or a little less than a mile, per hour. To this should be added the flow, for a few minutes only, caused by the extreme head, averaging 3 in. per mile, which would be about 2.9 miles per hour. In normal periods, the water of the Chagres would cause an additional flow of about 1 mile per hour, giving a total average velocity, at extremes of tide, of 4.9 miles per hour. Is such a current sufficiently dangerous to require the protection of gates?

When a marsh or lake of any considerable area has a narrow outlet to tidewater, and the entire surface has to be drawn off or refilled, the velocity in the outlet becomes very high. This may be seen, for instance, at Bocachica, the narrow entrance, and one of the three only outlets, of the extensive harbor at Cartagena. Here the tidal flow is quite rapid, though the total tidal variation is less than 3 ft. at spring tides; yet, though the entrance to this harbor is considerably narrower than the proposed canal-section, steamers entering and leaving that port entirely disregard the tidal action.

About seven years ago I sailed from New Orleans at a time when the Mississippi was higher than it had been for many years. The news of the rising flood was the principal topic in the daily press. The water was beginning to creep over the levees and cover the streets adjoining the wharves, and, with the ebb-tide, went booming down the restricted channel at a rate asserted to be from 6 to 7 miles per hour; yet the ocean steamers entirely disregarded this rapid current, beyond recognizing that they needed more steam to maintain a given speed against it, and correspondingly less steam when going with it.

The ebb-tide in New York Harbor during the spring months, when there happens to be an unusual flood, causes velocities in the North River which appear to me to exceed anything which could be anticipated under normal conditions at Panama.

The current of the Detroit River is said to run 4 miles per hour, without hindering the traffic.

The narrow channel of the harbor of Buenaventura, a day's steaming to the south of Panama, where the tides are equally severe, emptying, as it does, great lagoons behind and beyond the town, shows at times rapid currents; yet these have never hindered the entrance and departure of steamers.

I have made repeated canoe-trips on the rivers Anchicaya, Cajambre, and especially the San Juan, all

[11] Abbot, *Problems of the Panama Canal*, p. 115, Edition 1905.
[12] Abbot, *Op. cit.*
[13] Report of the Board of Consulting Engineers, p. 56, paragraph 2.

flowing into this section of the Colombia coast, with tidal variations similar to that at Panama. The current of these streams during the highest tides never has a velocity that would offer the slightest obstacle to steam navigation in both directions simultaneously, in a channel 300 ft. wide. Indeed, if high tides produced velocities dangerous to shipping, many of the British and European ports could not do business as they do at present.

I have been on steamers in the Magdalena River when they passed other steamers at points where the velocity exceeded 5 miles per hour, and the channel was narrower than that proposed at Panama. The upcoming steamer slightly slackens its speed, and the down-going one brings its velocity down to mere steerage-way. This is done because the great Magdalena steamers are flat-bottomed, and carry heavy deck-cargoes, which might be damaged by the waves raised by a steamer going at full speed.

After many years' experience in steaming and sailing, I can see no reason why the Panama Canal should be burdened with tide-locks at or near its Pacific outlet. The current would be a help to tows and sailing vessels which took advantage of it; and the slight extra vigilance required of the navigators of steamers would be more than compensated by the absence of the nervous strain of going through locks.

The absence of such tidal locks would, moreover, greatly reduce the fixed charges; the tidal current would carry away the silt; and the maintenance of the canal (except for a possible occasional slide, that could be readily dredged up), would be confined virtually to the care of the electric lighting system, the Chagres apron, and the collection of tolls.

With a canal built in this way, a constant stream of vessels could be kept in motion in both directions. If required, the American Navy could pass from one ocean to the other in a steady procession. Not believing in the advisability of tide-locks myself, and being by no means alone in my disbelief, I leave them out of my estimates.

As to accidents to the locks, the most ardent lock advocate does not deny the possibility of them. The experience at the Soo and at the Manchester Canal shows the mathematical certainty of accidents in the six locks at Panama. The sudden and violent gusts of wind encountered on the Isthmus may perhaps quite offset the advantage of electric controlling devices.

That intentional damage under the guise of accident is possible from hostile subsidized vessels is not to be denied. Mr. Parsons is on record before the Senate Committee as to his opinion that such accidents as are inevitable might drain off the lake to a point where a year would be required to refill for navigation.

A hostile force could only block such a sea-level canal as I propose with no dams for river control by sinking at great cost, a vessel in the channel of a sea-level canal, which could be removed in a week or two by dynamite and a wrecking crew. The recent reported contracts of the Wright Brothers to build an aeroplane to carry half a ton, and their marvelous trials in Europe, make the war aeroplane, with its great speed, silent and unnoticeable at night, an engine of war that, guided by the glimmer of the waters, could readily drop with accuracy a destructive charge before a single gun were pointed. When submarines and spies would have to be guarded against as well, it is clear that a sea-level canal would have a great advantage in war times.

As to rapidity of navigation, it is unlikely to be disputed that a vessel could pass through a sea-level canal of the 300-ft. type I advocate considerably quicker than through a lock canal. When a vessel grounds in the sea-level canal, the next tide will probably take her off; but in a lock canal the cargo must be lightered at great expense and loss of time.

The swampy ground where on a level with the water in the canal, will drain into it no material that will not readily flow off in the tidal currents. The Atrato River is deepest through its 100 miles of swamp borders where the current is slowest, and its banks frequently quite steep. Various other tropical rivers show the same, as do the Louisiana bayous and many tidal estuaries. The swamps near Gatun and Bohio, where as cited the canal would be respectively 50 ft. and 70 ft. below their levels, would necessarily cease to be swamps with such a huge drainage canal through them, and become solid and harmless flats. Such streams in sand and gravel in the Culebra Cut as shown in Fig. 6, on page 247 of Engineering News, would be equally harmful to the lock type unless cared for by spillways, which for all these streams in rock and gravel are "a perfectly simple and easy matter to build."

It is deplorable that the Editor of Engineering News quoted the old convent arch as an evidence that there had been no serious earthquake for over a century. Since the time of Pliny the shelter of a masonry arch has always been regarded in earthquake countries as the safest place in time of shock when an open field could not be reached. For an arch to fall it is mathematically necessary for its versed sine or middle ordinate first to become zero, which is impossible except when its side supports are separated a distance equal to double the difference of half the chord of the arch and the chord of half the arch.

Earthquakes are of course one of the greatest menaces to a lock canal. A shock however severe could do no serious damage to the apron spillways of the sea-level type, as they would not be retaining masses of water, nor could serious slides be anticipated that would block the 300-ft. width of the canal. In a lock canal but a slight movement of the walls would jam the locks and possibly drain the lake. A slight fissure in the dam would result in the entire cutting out of the lake in a few moments with the inevitable ensuing destruction and several years shutting down of traffic.

The record given by General Abbot shows seven tremors and four light shocks. Since then (1895) there have been others. In 1882 there was a series of shocks one of which threw down many masonry buildings in Panama and left 2-in. cracks in thick walls. It also destroyed a village along the line of the canal and killed several people. Furthermore it threw a great bridge 1½ ft. out of line, ruined 19 miles of the Panama railway, and opened a fissure across Colon and another for three miles along the Chagres.

Another disastrous earthquake was reported in 1858 and another in the latter part of the previous century. With such a record is it safe or sane to construct works on the Isthmus intended for all time that are in the slightest degree vulnerable by seismic action? The record given by Dr. Nelson in "Five Years at Panama" of these events is so corroborated as to be indisputable.

One of the principal factors in deciding for the lock type was its advocacy by Mr. John F. Stevens. Mr. Stevens is quoted as stating before a club in Providence last winter that in his opinion the Panama Canal would be of no commercial importance, and that in time of war two complete navies would be required to defend it. If Mr. Stevens, a confirmed railroad man, expressed himself in this way, it is enough to eliminate the last shred of his influence and cause a reopening of the question.

The Panama Canal is a tremendous step in advance for the prosperity of the world and especially of the United States.

Night work is perfectly practicable in the tropics. If 9 hours per day produce 37,000,000 yds. per year, 24 hours will produce 98,000,000 with the present equipment and simply enough more to replace the equipment being repaired. Men are available—health conditions exist—Goethals has the executive ability. A sea-level tidal canal without menace of any description is practicable in as little time as a lock canal.

Captain Oakes, Secy. of the Board of Consulting Engrs., Capt. Corps. of Engrs., U. S. A., estimates such a tidal canal, 300 ft. wide at the yardage, of from 400,000,000 to 500,000,000 cu. yds. For present purposes we will use his mean of 450,000,000 cu. yds. Of this say 60,000,000 have been dug. We have left 390,000,000 to dig. The News of the 4th inst. insinuates that the Lobnitz gravity ram shattering method is an experiment. This is an error. This method is in use in a dozen countries shattering from the softest shale to the hardest flint at a cost of but a few cents per yd. The transaction of the London Engineering Conference of 1907 show some records of its use proving that it can shatter rock ready for dredging at 15 cts. per cu. yd. Near Buffalo the Empire Engineering Co.'s barge never makes over 25 blows to a penetration and the average per penetration is over 1½ yds. of the hardest flint.

Let us assume for argument that by present train and shovel methods, 100,000,000 yds. can be gotten out at 60 cts. per yd. from the cut, and the center of the cut brought down near to the water level. By that time two fleets of powerful dredges will have opened the canal to near Obispo and Miraflores, pumping the material over the bank to a safe distance for most of the stretches. Then when the cut is down to drainage limit a pair of powerful dredges could rapidly cut a narrow channel through the center. In their wakes other dredges would attack the sides and load fleets of huge barges that would be towed to sea and dumped outside the breakwaters to form protecting shoals.

The center cut could be opened in six months and there is no reasonable limit to the number or capacity of the dredges to follow.

The material on the sides could be washed down by monitors or blasted at not over 15 cts. per yd. Assuming all the submarine material to be rock it could be shattered for the same cost, although where interspersed with clay or earth the process would be much more rapid and consequently cheaper. Where the rock is too soft to shatter it could be dredged as in gold dredging practice, at still less cost. Ladder dredges of 2 cu. yds. per bucket are now in use and there is no mechanical or practical reason where on mammoth work the buckets should not be of 10 cu. yds. each. Dredging into barges could not be figured at over 15 cts. per yd. under the most adverse circumstances, and towing and dumping another 15 cts. For pumping over the banks 20 cts. might be allowed to satisfy the most fastidious.

No experimental machinery or methods should be used, but for many of the gravity rams, power rams under my invention could be advantageously used, and I see no impropriety in suggesting them when they are evident facts to every engineer accustomed to handling machinery and when Casimir Von Philp of the Bethlehem Steel Co. is prepared to build them under a guaranty, and especially when I should derive no profit from the Government's use of them.

With dredges, shattering barges, scows and tugs, the rate of excavation can be increased as desired and the canal finished well within four years. The cost from date would be for an assumed classification:

100,000,000 yds. at 60 cts.....	$60,000,000
50,000,000 yds. at 20 cts.....	10,000,000
50,000,000 yds. at 35 cts.....	17,500,000
200,000,000 yds. at 45 cts.....	90,000,000
Spillways, jetties, quarters, etc....	22,500,000
Total.....	$200,000,000

Intrinsically sea level will be worth more by the capitalized extra cost of operating the lock canal, which among other things would have more dredging in the cut than sea level would have because of the dead water. The change to sea level is inevitable. The sooner it is made the less the loss. Up to date the lock expenditures that could not be utilized for spillways are but a small fraction of the total. It is getting larger every day. With the canal built thus at tide level all the world would know that the Panama Canal would be open for traffic until the end of time. Reconsideration and action should be immediate.

Henry G. Granger,
M. Am. Inst. Mining Engineers.
43 Exchange Place, New York City, March 8, 1909.

[It is the policy of Engineering News to give fair space for the presentation of both sides of a controverted question. Mr. Granger has been perhaps the most prominent of those who have in good faith advocated the sea-level idea in the public prints, and we have therefore given him the opportunity of presenting his arguments above.

We have so fully stated the situation at Panama in our last two issues that it does not seem necessary to answer in detail all the points Mr. Granger raises. We will, however, raise a single question which the reader can answer for himself. The question is whether Mr. Granger should be accepted as a competent and reliable adviser on a matter of such grave importance. We do not doubt that he writes in good faith and believes in the figures and estimates which he presents for the cost of the sea-level canal which he advocates; but would an engineer who was competent to advise in so critical a matter venture to set up his own estimate of the cost of a piece of work located 2,000 miles away, and surrounded by a multitude of peculiar and difficult conditions, in contradiction to the detailed estimates of a whole corps of engineers of high standing, located on the ground and familiar with the work by practical experience?

We print elsewhere in this issue Col. Goethals' testimony before a Congressional committee in which he estimates the construction cost alone for a sea-level canal, only 150 ft. to 200 ft. wide, at $477,601,000, or nearly $200,000,000 more than the cost of the lock canal. For the 300-ft. wide sea-level canal advocated by Mr. Granger, the cost would be of course enormously increased. Now which estimate ought to command the confidence of the engineering profession and of the public, the one made by the engineers on the Isthmus who are charged with the responsibility for the work, or the estimate made above by Mr. Granger, which bears internal evidence in plenty of lack of knowledge as to the actual conditions to be met?

We presume, however, that Mr. Granger would say in defence of his figures that the engineers on the Isthmus base their figures on the use of ordinary standard methods and machinery for excavation, while he plans to use certain machinery which he thinks will revolutionize the cost of excavation.

The "basic idea" of Mr. Granger's claim—to borrow the terms of patent law—is that it is vastly cheaper to excavate rock under water by chopping it to pieces with steel chisels and dredging the fragments than by any other method, even by blasting and excavating with steam shovels in the dry.

This idea has been so widely advertised by

Mr. Granger and by the Frenchman Bunau-Varilla during the past few months that it may be well to say just a word or two concerning it. We venture to suggest that, possibly, the engineers who are responsible for the work at Panama are as familiar with the "Lobnitz gravity ram shattering method" as Mr. Granger, and quite as competent to judge of its merits—and demerits.

We happen to know that this general method was used in work done under the Corps of Engineers in this country more than half a century ago, with success under certain limited conditions, and with failure under others. Since Mr. Granger refers to papers before the Institution of Civil Engineers of Great Britain, we may refer him to two papers before that Society which have just been published and which deal with this very matter. The first, by Mr. Arthur L. Bell, records experience in submarine rock removal at Malta, where both Lobnitz breakers and submarine blasting was employed. The record shows that the Lobnitz rock cutter with two rams in *one year* of work, during which it was actually working 42.4% of the total hours in the year broke up 17,200 cu. yds. of rock. The costs are not given, but some idea of them may be gained from the fact that a crew of nine men is required on each shift to operate the vessel. Comparison shows that one of the steam shovels now working in the Culebra cut excavates and loads on cars as much material in a fortnight, working only 8 hours a day, as this ponderous rock breaker broke in a year working 24 hours a day!

The other paper, by Mr. Harold Berridge, is a general account of methods for the removal of submarine rock. The author reviews the records of experience with the Lobnitz and similar systems in various parts of the world and in comparison with submarine blasting. The author says that "the economical use of the rock breaker is confined to the weaker kinds of rock," and remarks that the cost of the large rock breaker used at Blyth was as great as the cost of six or seven drilling barges. He continues:

> In the author's opinion, drilling and blasting may be economically employed in any material that can be drilled. He also holds that it is the *only method possible* where such materials as granite, gneiss, igneous rocks or limestone occur in layers more than 3 ft. thick. Rock-breakers, on the other hand, are proved to work economically in shales, sandstones and similar soft rocks, and in small surface-thicknesses of the harder rocks, these being generally softer than the main body. At the Iron Gates of the Danube depths of 1.64 ft. were allotted to rock-breakers and greater thicknesses to boring and blasting.

These records, it will be noted, relate to submarine rock excavation. We know of no records anywhere which give the slightest foundation for the idea that rock can be excavated more cheaply under water by any method than in the dry. The whole experience of the engineering profession goes to prove the contrary.

If Mr. Granger is so far astray on economical methods of rock excavation, it will doubtless occur to many that he may be equally astray in his earthquake ideas. Since he quotes with approval Gen. Abbot, however, we would refer any of our readers who may still be nervous about earthquakes at Panama to Gen. Abbot's conclusive discussion of this subject on pp. 241-244 of his book. He shows there that "the Panama route traverses a region less exposed to such dangers than any other on the Pacific slope," and refers to the experience of the San Francisco earthquake to show how remote is the danger anyway to the massive structures of the canal.—Ed.]

Notes and Queries.

Regarding the Sparkman St. Bridge at Nashville, Tenn., described in our issue of Feb. 25, 1909, p. 199, Mr. H. M. Jones, Engineer of the Cumberland River Bridge Commission, wishes to make the following corrections:

First. The factor of safety used in designing was 4 instead of 3, the ultimate strength of the 1:2:4 concrete being assumed as 2,400 lbs. per sq. in.

Second. The maximum compressive stress on the top chords under the severest possible condition of loading does not exceed 600 lbs. per sq. in., instead of 900 lbs., as stated.

Third. An unsymmetrical live load of "two 16-ton street cars" is mentioned, when as a matter of fact the trusses were designed for a moving load on two tracks of trains of 40-ton motors with 30-ton trailers.

An Experiment in Individual Engineering Instruction.

At the beginning of the school year of 1906-07, at the College of Applied Science of the State University of Iowa, an experiment in individual instruction was undertaken under the direction of Prof. W. G. Raymond, Dean of the College. For this experiment in teaching engineering principles and practice, so far as the latter was necessary, a section was formed of twenty men, each one of whom was a volunteer. The conduct of the section's work was admittedly far from what it would have been under a complete system of individual instruction. It was impossible to supply instructors who could give a half day regularly to the work. The whole section was confined to one room for studying, quizzing and drawing—no matter what subjects were being pursued by the different men. Of course, experimental work in chemistry and physics was done in the regularly equipped laboratories.

The plans and results were briefly disclosed in an article by Dean Raymond, printed in "The Transit," a college publication. Portions of this article are here reprinted with the insertion, at proper points, of pertinent extracts from a letter, from Dean Raymond, dealing with further phases of the experiment.

That all the men should be in one room was a distinct disadvantage, for, while the greater advancement of some men in a given subject proved somewhat of a spur to the slower ones, the earlier passing of one to manual work, as drawing, in the same room, was demoralizing, those students lacking somewhat in self-control and concentration, finding altogether too much of interest in their neighbor's work.

In spite of many difficulties, the section as a whole completed the same proportion of a year's work that was done by the regular classes. Indeed, it did much more than the regular sections, since every man worked from two to ten times as many problems in a given subject in mathematics as the men of the regular sections worked. For instance, every man who completed the subjects, solved 1,000 problems in algebra, 300 in trigonometry and 400 in analytical geometry.

It was planned that each student should pursue a given subject for at least a half of each day until the subject should be completed, but where the subject consisted of theoretical and laboratory work, the whole day was to be given to it, the theory being studied in the morning and laboratory work performed in the afternoon.

Chemistry was the first subject undertaken, and this being a subject requiring both theory and practice, it was pursued all day. The theoretical work was finished ahead of the laboratory work, and so soon as any student finished his theoretical chemistry he devoted his mornings to algebra, and finishing algebra, began trigonometry. After the completion of the laboratory work the student devoted his afternoons to drawing and descriptive geometry.

The student is given a text-book, but is not told to merely absorb its contents until he strikes a rock. He is told to understandingly absorb its contents until he comes to a certain point or until he strikes a difficulty. The instructor quizzes the student as soon as he has arrived at the point suggested or, if by chance the instructor happens to be busy at the time with some one else, the student goes ahead with his text-book work in order not to lose time.

Sometimes several students of about the same ability would be expected to get to the same point of difficulty at the same time, and yet it is singularly rare that even students of about the same ability stumble over the same difficulty.

It is doubtful if we arrived at the best method of conducting this work, and it is practically certain that it is oftentimes best to handle the men in groups, these groups being varied according to the relative progress of the men, and containing anywhere from one to three or four men. But in our experience there never were more than two men at the same stage of progress. It is entirely probable that lectures or talks might be given to small groups from time to time as the work progresses. Possibly these should, in some subjects, be given as often as every day. These talks would be not so much explanatory of certain difficulties as on the applications of the subject covered.

As I see it, it is no criticism of the method to suggest that oftentimes two or three students may be progressing at the same rate and may be handled together as one. The method is still sufficiently individual to distinguish it radically from class work and is absolutely individual for the most part and whenever the individual seems to require it so.

The method may possibly be called a reversion, in some respects, to old-time methods which, in the writer's judgment, are very superior to modern class-room methods. It seems to be a fact that the method is obtaining favor, and is being carried out so far as it can be by different instructors, though not wholly anywhere so far as the writer knows. The tendency seems to be toward this scheme. The tutorial system of Princeton closely approximates it and perhaps is an improvement. Presumably this particular tutorial system came from the English universities, but it was adopted some time after the writer had described this method before the Society for the Promotion of Engineering Education a few years ago.

It was first thought that there should be not more than two subjects carried at once—a half day being given to each. On announcing this notion it was gratifying to learn that for some time this has been the method of instruction in the Thayer School at Dartmouth College. Although the work there is nominally class-work it approaches to individual instruction because of the limited number of students in the classes.

The method is as much a test of the instructor as of the student, and many a teacher who could go on indefinitely under the ordinary class method of recitation or lecture, would soon find his Waterloo under the individual method. He must have the whole of the particular subject he is teaching at his fingers' ends; he must be warmly sympathetic, yet able to distinguish between the need of sympathy and the need of a prod; he must know how to teach by leading the student to think logically for himself rather than by full and complete explanation, which is always easier; he must be able to dominate the atmosphere of the room, keeping it warm and cordial, yet snappy and business like; and he must be faithful to his hours, and not a time server.

The writer, both because of lack of other available instructors and because he wished the experience, carried the section through two subjects. While the work required long hours it was not so fatiguing as either lecture or sharp quiz work, and it was by far the most interesting teaching the writer has ever done.

Some things of interest were noted. The rule was proved that while a man may have his special line of work, the normal student is either good or poor or average in everything, the abnormal man can do one thing much better than another. The man first through in chemistry theory failed utterly to master algebra and dropped out. The fourteenth man to finish the theory of chemistry was second in time required for algebra. Two men finished the year's work three weeks before the close of the year: one of these men worked constantly, night and day, and seemed to enjoy it, while the other was partly self-supporting, played in the band, did the equivalent of one and one-sixth years of college work, and always seemed to have plenty of time.

One man, it was thought for a while, would never master descriptive geometry, and had he been in a regular class would undoubtedly have failed, because before he began to see it at all so much time had elapsed that a regular class would have been far beyond the possibility of his catching up with it. But once he had it, he went ahead by leaps and bounds, and finished well within the allotted time. Other men, fully as able as he, failed utterly in the regular classes and dropped out early in the course.

It is believed that there were two students in the section who failed to complete the year's work who might have completed it under the usual class method, but it is also believed that they would have done their work much less thoroughly.

It is believed—indeed, it may be said that it is known—that there were several students in the section who would have been entirely lost at an early stage of ordinary class work in several subjects that were completed in most creditable fashion at a slow rate.

Four results that may be of interest are these:

(1) There were only four men—20% of the section—who covered satisfactorily all the work required, and all of these could have done, and three did do, more than the required work in the required time, thus setting themselves distinctly in a class by themselves, though differing greatly from each other in their methods and capacities. Only four men—20%—of the regular class in civil engineering, passed the year's work with a clean record, making this result alike in both sections. A little larger percentage—about 25%—of the entire freshmen class made a clean record.

(2) The record shows about the same total proportion of a year's work accomplished by the individual section as a whole and the remainder of the class. The proportion was about 75%.

(3) The ratio of work accomplished by the most advanced and least advanced students of the individual section is as 177 to 100, and if the most advanced student had remained to the end of the year at the same rate the ratio would have been 188 to 100. In this connection it should be remembered that this most advanced student was wholly or in part self-supporting, played in the university band, which required more time than the usual military service, and was also in the regular class during the first semester, his gain being almost wholly made in the last half of the year.

(4) The most advanced student would complete the regular curriculum in approximately three and one-

quarter ordinary school years, and could probably do it in three years. The least advanced would complete the work in six years, or possibly less. But if the school year might be, say, forty-six weeks long, the time required would be two and one-half calendar years and five and one-quarter calendar years, respectively.

The first and second of the foregoing results seem to indicate that several classes of men taught by different methods will reach approximately the same level of accomplishment, but this interpretation is not quite correct, because the individual work was not conducted with the same relative efficiency as the regular class-work, and the true indication, therefore, is that a measurable excess of accomplishment is possible under the individual plan. The four results, considered together, indicate the extent to which the man of quick intelligence is held back to the average in ordinary class-work, and the liability of the slow man to fail, be he never so faithful, because he cannot reach the average.

The third and fourth items seem to indicate that the quick student may get permanently into his profession from three-fourths of a year to one and one-half years earlier, if taught by the individual method, or he may secure a much broader education in the usual four years. It is not forgotten that summer vacation work when it is secured is valuable training, and that the proper length of the school year is an open question distinct from the question of individual instruction. The results indicated may, however, be considered contributions to the discussion of both questions.

The second year's work with this section has put the most advanced student so far ahead that it is now certain that he will complete his course in three years. The others are at various stages of their progress, and because of failures or removals from the university, the section has been reduced to eight men, and, owing to the impossibility of supplying the necessary instructors the section will not be carried beyond this year.

It is interesting to note that one instructor reported this section as the best he had ever taught in his subject, in spite of the fact that, as a whole, the men of the section were slower than the better men of regular sections.

As to the grasp obtained by those men who never would have succeeded by the ordinary method, in general it was most excellent. All sorts of engineers are needed; the men who have the initiative to see what needs to be done, and to design the method of doing it; the men who, when they are told what needs to be done, are able to design the method of doing it; and the further class of hack men who are capable of working out details from the general designs furnished them. Some of the men in our experimental group, who were slow, will fall perhaps into the last of these three groups but at least one of them belongs certainly to the middle group and possibly to the upper group. This man is the one whose work in descriptive geometry was mentioned. It was not lack of ability to do the work that prevented his quick start. I am not quite sure what it was, but it may be attributed to lack of previous preparation. That same boy who did his work beautifully the first year came back last year and went into the regular classes, in which he failed to continue the record of the previous year.

Granted that these men who are helped through may make no more than the lowest rate engineers, yet unless they are better fitted for some other calling, it appears wise to help them to this lowest order rather than to abandon them and to give them no training at all. The careful instructor watches his men and decides in his own mind whether or not they are in the right line of work and advises them accordingly. This, it would seem, is one of the good points of the system. We do not hesitate to advise a young man to abandon engineering for literature or law if we find that his abilities seem to point more in these directions.

The most advanced young man of this special section will graduate this year, making his course in three years, and all the time standing at the head of his class. Another will probably graduate in three years and a half. The first of these men will belong in the first of the three classes of engineers made; and in spite of his rapid advancement we are not sure that the other will ever make more than the third class. So far as I have been able to judge, and I have studied his case very carefully, he is as well adapted to this work as to any other, unless it be commerce.

The writer has a feeling that many of these men have been helped through a critical period of their lives when, because of lack of will-power, they would have utterly failed in regular class work. Help of this character is valuable.

A distinct advantage of the individual method, so patent that it need not be elaborated, is the opportunity given to any man, graduate or undergraduate, to enter at any time upon any subject for which he is prepared, and to follow it to any desirable or possible extent. The possibilities to the graduate student, to the undergraduate student of limited means, who can conveniently work but part of the year, and to the mature man desiring to investigate a single field, are very great, and the method in this particular seems to conform in the highest degree to the true university idea.

The writer is thoroughly convinced that this is the rational method of instruction in engineering, and very much regrets that the impossibility of supplying the necessary double set of instructors in this college, because of its dependence upon the work of the college of liberal arts, makes it impossible to adopt the method wholly.

It is worth noting, however, that the department of descriptive geometry and drawing, as a result of its experience in this work, has, it is believed with great advantage to its students, materially modified its method of instruction, and the surveying work will likewise be taught in approximately the same manner as has been used with the individual section.

Testimony of Col. Geo. W. Goethals, Chief Engineer of the Panama Canal, before the House Committee on Appropriations.

We take from the official report of Col. Goethals' testimony those parts which make comparisons of the Lock and Sea Level plans for the canal as follows:

The Chairman.—You have heretofore approved the lock type of the canal?

Colonel Goethals.—Yes, Sir.

The Chairman.—Have you or any of your associates discovered anything in connection with the work of constructing the canal upon which you have been engaged that would tend to change your opinion regarding the wisdom and practicability of a lock-type canal since you first commenced work on the canal?

Colonel Goethals.—No, sir. On the contrary, the longer we stay the more convinced we become that the lock-type canal is the proper type of canal to build.

The Chairman.—Will you explain somewhat in detail what the reason is for that statement?

Colonel Goethals.—The great problem in the construction of the canal is the control of the Chagres River. The Chagres River by the lock type of canal is controlled by a lake, formed by the construction of the dam at Gatun, the lake level to be at 85 ft. above mean tide. In the sea-level project, the control of the Chagres River is effected by the dam at Gamboa.

The Chairman.—What is the distance from Gatun to Gamboa?

Colonel Goethals.—It is about 24 miles. The dam there at Gamboa is 4,500 ft. long. Seven hundred and fifty feet in the length of that dam has pressure against it due to a possible head of 170 ft., or practically twice the head of water that acts on the Gatun dam. In the sea-level type of canal the minimum width at the bottom is 150 ft. through earth, or for about one-half of the length of the canal, the balance of it being about 200 ft. in width at the bottom. The sea-level canal is tortuous and will be difficult of navigation.

A great deal has been said about the danger to the canal because of the Gatun dam. They purposely or through ignorance omit all mention of the Gamboa dam, which would be just as essential to the sea-level type as the Gatun dam is to the lock type. They failed to mention the necessity of tidal locks at the Pacific end, the destruction of which will be just as detrimental to the sea-level type as to the lock type. They also failed to mention the additional length of time and the additional amount of money it would take to build it, and they failed to mention the increased difficulties in the construction of the sea-level canal because of the enormous fluctuations in the Chagres River.

Mr. Fitzgerald.—Can you state the relative comparison between these two dams to which you refer—the one required by the sea-level type and the other by the lock type—as to the size and pressure?

Colonel Goethals.—The Gamboa dam, required by the sea-level type, was recommended by the Consulting Board to be built of concrete. The maximum of pressure to which the Gamboa dam will be exposed was estimated by the board to be due to a head of 170 ft. The top of that dam would be 180 ft. above sea level. The Chagres River must be diverted in order to enable the construction of that dam.

The Gatun dam has a length of about a mile and a half over the total distance of about 7,000 ft.; but part of that is occupied by the spillway, so that we have in fact at Gatun three dams; a short section from the locks to spillway hill, the spillway proper, which is of concrete, and then another dam extending from the spillway to the hills on the west. The thickness of that dam at the top is 100 ft. It is to be constructed of earth by the hydraulic process. The thickness at the bottom is half a mile. The thickness at the water surface is about 500 ft. through.

Mr. Fitzgerald.—What is the total pressure?

Colonel Goethals.—Due to 85 ft. head.

The Chairman.—You say you have found rock, and found it throughout the entire length of the Gatun dam?

Colonel Goethals.—Yes. But you know we have two deep gorges which have caused considerable criticism. So much question was raised at the hearing before the Senate committee last year concerning the character of the material that is to underlie the Gatun dam that when I returned to the Isthmus I decided to investigate those dam foundations, and started to make a test pit in one of the gorges down to the rock, examining the material from the surface to the rock. Certain criticisms had been made concerning the deposit of gravel, water-bearing gravel, which was reported to exist in these foundations. In conjunction with this test pit we made a number of borings. The borings differed from those that had previously been made, in that whenever the character of the material changed, drive samples of the material as it exists in place were taken out and examined. The test pit was sunk to a depth of about 90 ft. below the surface of the ground, or about 80 ft. below the sea level. The borings made in the vicinity of the pit showed the same character of material that we had been finding in the borings which extended to the rock, so that I abandoned the pit as an unnecessary expense and sank within the limits of the pit three borings down to the rock.

The Chairman.—What depth did you go before striking the rock?

Colonel Goethals.—In the center of the gorges, approximately 270 and 260 ft. The layer of shells and the layer of gravel and bowlders that had been reported as existing were found to be shells, gravel, and stones of various sizes firmly embedded in clay. When the borings were first made, consisting of wash borings, the water under pressure had washed away the clay between the gravel, so that the material brought to the surface appeared as loose gravel. Our drive samples and also our test pits showed this material to be surrounded by clay, compact and hard and absolutely impervious to water. We have made such examination of the foundations as to leave no question of doubt as to the material and position in which the varying materials lie in these various strata from the top to the bottom. We also made examinations to determine the percolation of water under pressure through those various strata, and we find that the foundations are impervious, with the exception of the top layer, consisting of sand and clay, varying in thickness from zero to 80 ft. That is the only pervious portion of the dam foundations. There is no question in the mind of any one that the foundations are better than the Consulting Board concluded existed at the time their report was made.

Estimate for Sea-Level Canal.

Mr. Fitzgerald.—You said earlier in your statement that the criticisms that were being made did not mention the increased cost that the sea-level canal would involve. Have you made an estimate of what the sea-level canal will cost now, from your latest information?

Colonel Goethals.—For construction and engineering alone, exclusive of sanitation and civil government—which we estimate at the rate of $2,800,000 a year—and based on the fact that the sea-level canal will take at least six years longer to build, the sea-level canal for construction and engineering alone, exclusive of sanitation and civil government and the purchase price, would cost $477,601,000.

Mr. Fitzgerald.—And would take six years longer?

Colonel Goethals.—Yes; six years longer, and $2,800,000 a year for sanitation and civil government. And then I must add that these estimates are based on the units of cost as we have them to-day, and also are based on data which we have not verified, of French maps, for a large portion of the excavations.

Mr. Fitzgerald.—So that, including the amount paid to Panama and to the company and the cost of sanitation and civil government, the sea-level canal, upon the information you now have, will cost $563,000,000, as against $375,000,000 for the lock type?

Colonel Goethals.—Yes; that is, the completed canal.

Mr. Smith.—Did I understand this $375,000,000 would include the interest during the period of construction?

Colonel Goethals.—No, sir; nor does the $561,000,000 include the interest on the money during construction, which interest should be added to the sea-level canal for the extra period of time necessary to complete it, in order to form a fair basis of comparison.

Mr. Smith.—What will be the entire period of years from the inception of expenditures on this canal to its completion, on the lock type?

Colonel Goethals.—The year 1904 saw its beginning, and January 1, 1915, will see its completion. That is 10½ years.

Mr. Fitzgerald.—Colonel, have you any reason to believe that the information you have, based on the reports of the old company, upon which you based this cost of the sea-level canal, would turn out to be as inaccurate as the other information, so that the cost of the sea-level canal would really be greater than this?

Colonel Goethals.—We have reason to believe that the cost will be increased as new surveys are made of the section of the canal to be excavated to the sea level. We had to take the best data we have for a greater portion of the canal. For the parts we have surveyed they show an increase in quantity over the French survey.

The Chairman.—Colonel, recently a statement was made to this effect:

The latest estimated cost of the lock-type of canal, including the purchase price of the canal rights and of the Canal Zone rights—$50,000,000—will bring the present estimated cost to $400,000,000, more than $200,000,000 in excess of the sum originally estimated and more than $100,000,000 in excess of the conceded maximum cost of the sea-level canal.

Colonel Goethals.—The writer of that article or the maker of that speech failed to consider that the same conditions which raise the cost of the lock type of canal would also tend to raise the original estimates of the sea-level canal.

Mr. Sherley.—Even in a greater degree?

Colonel Goethals.—Yes, even in a greater degree.

The Chairman.—You say that, after your two years' experience and observation in the work of constructing the canal, neither you nor your associates have discovered anything in the physical condition there that would tend to change your opinion or judgment as to the relative merits of the two types of canal?

Colonel Goethals.—No, sir.

The Chairman.—Have the conditions confirmed that judgment?

Colonel Goethals.—Yes, sir.

President Taft on Government Regulation of Railways and Industrial Combinations and on the Panama Canal Work.*

The office of an inaugural address is to give a summary outline of the main policies of the new administration so far as they can be anticipated. I have had the honor to be one of the advisers of my distinguished predecessor and as such to hold up his hands in the reforms he has initiated. I should be untrue to myself, to my promises and to the declarations of the party platform upon which I was elected to office if I did not make the maintenance and enforcement of those reforms a most important feature of my administration.

They were directed to the suppression of the lawlessness and abuses of power of the great combinations of capital invested in railroads and in industrial enterprises carrying on interstate commerce. The steps which my predecessor took and the legislation passed on his recommendation have accomplished much, have caused a general halt in the vicious policies which created popular alarm and have brought about in the business affected a much higher regard for existing law.

To render the reforms lasting, however, and to secure at the same time freedom from alarm on the part of those pursuing proper and progressive business methods, further legislative and executive action are needed. Relief of the railroads from certain restrictions of the anti-trust law have been urged by my predecessor and will be urged by me. On the other hand, the administration is pledged to legislation looking to a proper federal supervision and restriction to prevent excessive issues of bonds and stocks by companies owning and operating interstate commerce railroads.

Then, too, a reorganization of the department of justice, of the bureau of corporations in the department of commerce and labor and of the Interstate Commerce Commission looking to effective cooperation of these agencies is needed to secure a more rapid and certain enforcement of the laws affecting interstate railroads and industrial combinations.

I hope to be able to submit at the first regular session of the incoming Congress in December next, definite suggestions in respect to the needed amendments to the anti-trust and the interstate commerce law and the changes required in the executive departments concerned in their enforcement.

It is believed that with the changes to be recommended American business can be assured of that measure of stability and certainty in respect to those things that may be done and those that are prohibited, which is essential to the life and growth of all business. Such a plan must include the right of the people to avail themselves of those methods of combining capital and effort deemed necessary to reach the highest degree of economic efficiency, at the same time differentiating between combinations based upon legitimate economic reasons and those formed with the intent of creating monopolies and artificially controlling prices.

The work of formulating into practical shape such changes is creative work of the highest order and requires all the deliberation possible in the interval. I believe that the amendments to be proposed are just as necessary in the protection of legitimate business as in the clinching of the reforms which properly bear the name of my predecessor.

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The Panama Canal will have a most important bearing upon the trade between the eastern and far western sections of our country and will greatly increase the facilities for transportation between the eastern and the western seaboard and may possibly revolutionize the transcontinental rates with respect to bulky merchandise. It will also have a most beneficial effect to increase the trade between the eastern seaboard of the United States and the western coast of South America and indeed with some of the most important ports of the east coast of South America reached by rail from the west coast.

The work on the canal is making most satisfactory progress. The type of the canal as a lock canal was fixed by Congress after a full consideration of the conflicting reports of the majority and minority of the consulting board and after the recommendation of the War Department and the Executive upon those reports. Recent suggestion that something had occurred on the Isthmus to make the lock type of the canal less feasible than it was supposed to be when the reports were made and the policy determined on led to a visit to the Isthmus of a board of competent engineers to examine the Gatun dam and locks which are the key of the lock type. The report of that board shows that nothing has occurred in the nature of newly revealed evidence which should change the views once formed in the original discussion. The construction will go on under a most effective organization controlled by Colonel Goethals and his fellow army engineers associated with him and will certainly be completed early in the next administration, if not before.

Some type of canal must be constructed. The lock type has been selected. We are all in favor of having it built as promptly as possible. We must not now, therefore, keep up a fire in the rear of the agents whom we have authorized to do our work on the Isthmus. We must hold up their hands, and, speaking for the incoming administration, I wish to say that I propose to devote all the energy possible and under my control to the pushing of this work on the plans which have been adopted and to stand behind the men who are doing faithful hard work to bring about the early completion of this the greatest constructive enterprise of modern times.

*Extracts from the Inaugural Address.

Notes from Engineering Schools.

UNIVERSITY OF ILLINOIS.—The United States Geological Survey, in cooperation with the State Geological Survey, has established at the College of Engineering, University of Illinois, Urbana, Ill., a Mine-Explosion and Mine-Rescue Station. The purpose of the station is to interest mine operators and inspectors in the economic value of such modern appliances as oxygen helmets and other resuscitation apparatus as adjuncts to the normal equipment of mines. The station also will concern itself with the training of mine bosses and others in the use of such apparatus. Its service is to be rendered gratuitously, and so far as possible to all in Illinois, Indiana, Michigan, West Kentucky, Iowa and Missouri, who may desire.

The formal opening of the station is to constitute a part of the proceedings of a Fuel Conference, which is to be held at the University of Illinois, March 11 to 13 inclusive, under the auspices of the Technologic Branch, U. S. Geological Survey, of the Illinois Geological Survey and of the College of Engineering. On the first of the days named, the rescue station will be formally opened with addresses by President E. J. James, University of Illinois; Mr. J. A. Holmes, U. S. Geological Survey; Mr. A. J. Moorshead, Illinois Coal Operators; Mr. T. L. Lewis, United Mine Workers. There will be demonstrations of the use of oxygen helmets and in resuscitation work. In the evening of this day there will be addresses on the prevention of mine explosions.

The second day's first session will be devoted to explosives and explosions, and the second session will be a conference on smoke suppression. The first of the third day's session will be given over to addresses on first-aid work in mines and on the work of the Illinois Engineering Experiment Station. On the afternoon of this day there will be a conference on economy in the use of fuels. On the last day of the meeting there will be a single session, with three addresses; one on the fuel resources of the country, one on the fuel resources of Illinois and a third on the analysis of coal.

A POWDER MILL EXPLOSION at Kings Mills, Ohio, March 1 destroyed the smokeless powder plant of the King Powder Co. and killed one of the employees.

Two mills of the Du Pont Powder Co., near Wilmington, Del., were wrecked by an explosion March 8. One man was killed and several injured.

THE PREMATURE EXPLOSION OF A BLAST in the Diamond mine, near Butte, Mont., March 3, killed four miners and injured one other.

An explosion at the Vankleek gold property in Elzevir Township, ten miles northeast of Madoc, Ont., March 5, killed two men and injured as many others. The accident was caused by an unexploded charge which was struck by a drill.

A COAL MINE EXPLOSION at the No. 14 colliery of the Erie Coal Co. in Port Blanchard, Pa., March 2, killed two miners and severely injured twelve others. The explosion is attributed to the accumulation of gas in an old working. The fire which followed the explosion was extinguished only after several hours of hard work, but it is stated that the damage to the mine was comparatively slight.

A TORNADO IN ARKANSAS March 8 swept through the central portion of the state, crossing the Arkansas River within five miles of Little Rock and completely wrecking the town of Brinkley in Monroe Co. Reports state that the business section of Brinkley is in ruins and that there is scarcely a home in the city that has not suffered heavy damage. About 30 persons were killed and twice that number were injured. A fire followed the storm, but was soon extinguished.

A cyclone in Georgia March 9 destroyed a considerable portion of the business section of the town of Cuthbert, including the city lighting plant. Six persons were killed and several injured.

A COMPOUND STREET-CAR COLLISION on Blue Hill Ave., Boston, Mass., March 3, in which seven cars were involved, killed one of the motormen and seriously injured nine passengers. The accident occurred at the foot of a slight grade which extends from Charlotte to Abbott St. The rails were covered with a light layer of snow. The first car attempted to stop at Abbott St., but slid along some distance before stopping. A second car, closely following, was likewise unable to stop and crashed into the first, wrecking the vestibules. This was repeated by five succeeding cars. The eighth car was stopped at the top of the slope, which has a length of about 200 yds.

A SEWER CAVE-IN AT SEATTLE, WASH., Feb. 23, killed two men and imprisoned nine others in the tunnel of the Northern trunk sewer which is being driven within the grounds of the Alaska-Yukon-Pacific exposition. The roof of the tunnel in which the nine men were imprisoned for 21 hours is 34 ft. beneath the surface. The men were supplied with food and air through a pipe driven into the tunnel from above.

A sewer cave-in on Germantown Ave., Philadelphia, March 4, resulted in the death of two workmen. An attempt was being made to relieve conditions caused by an obstruction in the sewer by making a temporary connection at a point above the obstruction. Reports state that the pipe burst as soon as it was uncovered by the excavation, due to the increased pressure occasioned by the obstruction. The escaping water caved the walls of the trench and quickly flooded it, drowning two of the workmen.

THE EXPLOSION OF A BOILER at the Beck sawmill, five miles from Thomasville, N. C., March 1, instantly killed one person and fatally injured two others.

The boiler of a locomotive drawing a passenger train on the Cincinnati, Hamilton & Dayton Ry. exploded near Findlay, Ohio, March 1, killing the engineer and fatally injuring the fireman.

A TENEMENT HOUSE FIRE on Seventh Ave. in New York City, March 3, caused the death of ten of the tenants. The fire started early in the morning and was not discovered until it had gained such headway as to make the stairway impassable. There were about 60 people in the building, a five-story structure, and all of these but the ten who were killed either descended the fire-escape at the rear or were rescued by ladders from the front windows. Those killed were suffocated by smoke on the fifth floor and appeared to have made no effort to escape.

A STEEL RAIL ORDER OF 101,000 TONS has just been placed by the New York Central Lines. The order was distributed as follows: Lackawanna Steel Co., 51,000 tons; U. S. Steel Corporation, 42,600 tons; Algoma Steel Co., 5,400 tons and the Bethlehem Steel Co., 2,000 tons. Part of the tonnage is to be open-hearth steel and part of Bessemer. And some of the Bessemer metal is to contain ferro-titanium, in continuation of some very successful experiments with this alloy that the New York Central lines have been carrying on in the past few years. The rails are to be rolled in the old standard Am. Soc. C. E. sections, but under new rolling specifications recently issued by the railroads, which specifications, it is hoped, will remedy a number of the defects in rails due, not to the metal, but to the rolling.

PANAMA CANAL EXCAVATION during February surpassed all previous daily records, with an average daily output of 136,908 cu. yds. The largest previous daily average was 133,857 cu. yds. during the month of March, 1908. During February, 1909, the excavation totaled 3,148,879 cu. yds., for the 23 working days, as against a daily average of 116,982 cu. yds. for the 25 working days of January, a total of 2,924,551 cu. yds. The record for the past two months follows:

	Feb.	Jan.
Steam Shovels:		
Atlantic division	107,865	114,665
Central division	1,546,008	1,452,953
Pacific division	101,432	138,109
Dredging:		
Atlantic division	577,201	573,321
Pacific division	692,198	490,584
	3,024,704	2,769,632
Accessory work outside canal prism:		
By steam shovel	124,175	110,147
By dredging	....	44,772
	3,148,879	2,924,551

The rainfall during February was 2.85 ins. as against 4.39 ins. in January.

A DYNAMITE COMMISSION has been appointed by the mayor of Chicago, following the recommendation of the jury in the recent investigation of the fire at the crib of the new water tunnel, as reported in our issue of Feb. 25. The commission will consider the proper methods of handling and thawing dynamite, and the preparation of ordinances and regulations governing the storage and use of explosives. The commission is composed of the following members: A. Bement, engineer; Benezette Williams, engineer; John M. Ewen, engineer; Arthur E. Paul, chemist and powder expert; C. R. Cave, merchant; Edward C. Rice, powder manufacturer; James Horan, Fire Marshal; John J. Hanberg, Commissioner of Public Works; John Ericson, City Engineer and alderman; W. P. Dunn and Michael Zimmer. The first five members were members also of the jury above noted.

A SPECIAL THEATRICAL TRAIN ran from Boston to Pittsburg, 775 miles, in 17½ hours on Feb. 28. The train went over the Boston & Albany, New York Central, Lake Shore and Pittsburg & Lake Erie roads. It consisted of five Pullman sleepers, a dining car, an ordinary coach and five baggage cars, drawn by two engines. The running time between Buffalo and Pittsburg was 5 hrs. and 10 min., which is said to be 55 min. better than any previous record. The average speed for the whole distance was about 44 mi. per hr.

RAPID WORK BY STEAM SHOVELS.—Fourteen shovels in the Empire District, Central Division, on Feb. 17, 1909, excavated 22,286 cu. yds. of material in a working day of eight hours, an average of 1,592 cu. yds. per shovel for the day. The shovels were under steam a total of 112 hours and were actually digging 79 hours and 30 mins. The time not spent in digging is accounted for as follows: Cleaning track, 1 hr. and 25 mins.; waiting for cars, 23 hrs. and 10 mins.; mining, 1 hr. and 55 mins.; cleaning dipper, 1 hr. and 45 mins.; repairing shovel, 3 hrs. and 25 mins.; coaling shovel, 30 mins.; sliding, 20 mins.

On Thursday, Feb. 18, 1909, seven shovels in the Tabernilla Construction District, Central Division, during eight working hours, excavated 11,450 cu. yds. of material, an average of 1,636 cu. yds. per shovel for the day. The shovels were under steam 56 shovel-hrs. and were actually digging 48 hrs. and 5 mins. of this time.—"Canal Record," Feb. 24.

A WARSHIP WITHOUT FUNNELS, to be driven by gas engines, has just been laid down by Great Britain. This new boat, the "Indefatigable," is of the "Dreadnought" class and is the result of a number of experiments by the British admiralty, which seem to show that internal combustion engines will not only allow more deck room for the armament, but will prove more economical in construction and operation.

RAILWAY RATE LEGISLATION in Missouri was nullified on March 2 in a decision by Judge McPherson of the U. S. District Court. He held that the 2 ct. a mile passenger rate law and the maximum freight rate law enacted in 1907 reduced the earnings of the railways affected to such a point as to practically confiscate the property of the owners of railway lines. The court gave as its opinion that a railway properly built and properly managed should make a return to its owners of at least 6%. Under the rates fixed by the law he found that the returns were from 2 to 5%, where the extra cost of local business was not considered. When this extra cost was included, the earnings were all absorbed by the expenses.

A TUNNEL BENEATH THE DELAWARE RIVER, between Philadelphia and Camden, is proposed by the Intercity Link Tunnel Co., which appears to be an adjunct of the Camden Tunnel Railway Co. A suit to prevent the construction of the tunnel, on the ground of losses through competition, was brought by the Philadelphia & Camden Ferry Co. The New Jersey Court of Errors and Appeals has just affirmed the decision of the Supreme Court of the same state, to the effect that the ferry company is not entitled to damages for any prospective loss of business on account of the proposed tunnel. Ordinances in connection with this general scheme are now before the City Council of Camden.

THE PURCHASE OF THE THACKERAY GARBAGE incinerating plant built at San Francisco some years ago by a company known as the Sanitary Reduction Works, has been arranged for by the city of San Francisco. It is understood that bonds for the purpose were included in the recent sale of $5,400,000 of bonds for various city improvements. The city is to pay $400,000 for the incinerating plant and for the franchise rights of the company. The franchise has some 40 years to run. It virtually provided that all garbage collected in the city must be taken to the incinerating plant, and that the company must be paid a stipulated rate for burning it. The private scavengers engaged in collecting the refuse of the city organized themselves into an association some years ago and fought this franchise provision, but were beaten. The franchise and the litigation were both outlined in Engineering News of May 17, 1900, in connection with a lengthy illustrated description of the incinerating furnaces.

AMERICAN SHIPBUILDING during the fiscal year ending June, 1908, surpassed all previous records. The total number of vessels built during that period was 1,457, with a gross tonnage of 614,216. It will be a matter of surprise to most Americans that the United States ranks only behind England in the aggregate documented merchant shipping, with 25,425 vessels, gross tonnage 7,365,445, as against the 11,563 vessels, gross tonnage 18,709,537, of Great Britain. Germany ranks next with 2,173 vessels having a gross tonnage of 4,232,145. However, most of the large shipping of this country is carried on the Great Lakes or in purely domestic coastwise trade and the seven seas see but little of the American flag. It was noted on the recent world-circling cruise of the American fleet that an American ship in a foreign harbor was a rare thing.

Personals.

Mr. Arthur M. Kinsman, Engineer of Construction of the Baltimore & Ohio R. R., has been appointed Chief Engineer to succeed Mr. Daniel D. Carothers, deceased.

Mr. L. H. Raymond, Master Mechanic of the New York Central & Hudson River R. R. at High Bridge, N. Y., has resigned.

Mr. H. P. Mobberly, Assoc. M. Am. Soc. C. E., has resigned his position as Division Engineer of the Texas & Pacific Ry. at Boyce, La., to engage in the general practice of civil and hydraulic engineering. His office is now at 304½ South Jefferson St., Springfield, Mo.

Mr. F. S. Parrigin, Chief Engineer of the Jonesboro, Lake City & Eastern R. R., has resigned to become Engineer of the Cumberland River & Nashville R. R., under construction from Tateville, Ky., to Monticello, Ky.

Mr. W. C. McKeown, Assistant Superintendent of the Wyoming division of the Union Pacific R. R., has become Superintendent of the same division, succeeding Mr. H. L. Anderson, resigned.

Mr. W. H. Fenley has been appointed Signal Engineer of the Chicago Great Western Ry., to succeed Mr. C. A. Christofferson, resigned. Mr. Fenley was formerly Supervisor of Signals.

Mr. John C. Ostrup, M. Am. Soc. C. E., Professor of Structural Engineering at the Stevens Institute of Technology, has been elected a member of the Institution of Civil Engineers.

Mr. Geo. F. Fenno, for the last two years an insurance engineer with the Middle States Inspection Bureau, has resigned in order to join the staff of the Geo. H. Gibson Co., Advertising Engineers, Tribune Bldg., New York City.

Mr. H. S. Snyder, Vice-President of the Juragua Iron Co., has become President of that company with office at South Bethlehem, Pa. Mr. De Berniere Whitaker succeeds Mr. Snyder as Vice-President and General Manager, with headquarters at Santiago, Cuba, and Mr. E. M. Holmes, who was recently Assistant Superintendent of the Spanish-American Iron Co., at Daiguiri, Cuba, will succeed Mr. Whitaker as General Superintendent of the Juragua Iron Co., at Firmeza, Cuba.

Mr. Walter D. Buxton, Assistant Engineer, Bureau of Public Works, Manila, P. I., has been detailed to take charge of construction and irrigation work for the penal colony recently established by the Philippines Commission at Iwahig on the island of Palawan in the southwestern end of the archipelago.

Mr. William H. Adams and Mr. Robert J. Cummins have opened an office as civil and consulting engineers in the Ford Bldg., Detroit, Mich. Mr. Adams has been for several years Chief Estimator of the Trussed Concrete Steel Co., of Detroit, and Mr. Cummins has been his principal assistant.

Obituary.

Elijah E. Myers, who was a member of the board of examiners of buildings of the Chicago World's Fair in 1893, died March 5 at his home in Detroit, Mich. Mr. Myers is said to have designed the State capitols of Michigan, Texas, Colorado, Idaho and Utah and the Houses of Parliament at Rio de Janeiro, Brazil. He was born in Philadelphia, Pa., in 1832.

Howard Breen, M. Am. Soc. C. E., died Feb. 14 at his home in Pasadena, Cal. He was born at Louisville, Ky., in 1860 and was a graduate of the University of Cincinnati. He was for a number of years associated with the Keystone Bridge Co., of Pennsylvania, and had afterward practiced as a consulting engineer. For some time preceding his death he had been debarred from active practice by ill health.

Henry Bausch, Vice-President of the Bausch & Lomb Optical Co., died March 2 at Augusta, Ga. He was born at Rochester, N. Y., in 1859 and attended the public schools of that city. He took work as a special student at Cornell University in 1884-5 after having worked for nine years in the Bausch & Lomb factory. His principal work was in connection with the design of microscopes and scientific instruments.

Engineering Societies.

COMING MEETINGS.

RAILWAY SIGNAL ASSOCIATION.
March 15. At Chicago, Ill. Secy., C. C. Rosenberg, Times Bldg., Bethlehem, Pa.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.
March 16-18. Annual convention at Chicago, Ill. Secy., E. H. Fritch, 962 Monadnock Block, Chicago.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION.
April 27 to 30. Annual meeting at Louisville, Ky. Secy., H. D. Vought, 95 Liberty St., New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
May 4-7. Spring meeting at Washington, D. C., Secy., Calvin W. Rice, 29 West 39th St., New York City.

AMERICAN ELECTROCHEMICAL SOCIETY.
May 6-8. Annual meeting at Niagara Falls, Canada. Secy., Jos. W. Richards, Lehigh University, South Bethlehem, Pa.

AIR BRAKE ASSOCIATION.
May 11-14. Annual meeting at Richmond, Va. Secy., F. M. Nellis, 53 State St., Boston, Mass.

AMERICAN FOUNDRYMEN'S ASSOCIATION.
May 18-20. Annual meeting at Cincinnati, Ohio. Secy., Richard Moldenke, Watchung, N. J.

AMERICAN RAILWAY ASSOCIATION.
May 19. Annual meeting at New York City. Secy., W. F. Allen, 24 Park Place, New York City.

NATIONAL FIRE PROTECTION ASSOCIATION.
May 25-27. Annual meeting at New York City. Secy., W. H. Merrill, 382 Ohio St., Chicago, Ill.

ENGINEERS' CLUB OF BALTIMORE.—At the meeting of March 6, Prof. J. B. Whitehead, of Johns Hopkins University, presented a paper on "The Electric Operation of Steam Railways."

CANADIAN SOCIETY OF CIVIL ENGINEERS.—At the meeting of the general section to be held March 11 in Montreal, Mr. T. Kennard Thompson will present a paper entitled "Foundations of the Manhattan Life Building, New York," illustrated with lantern slides.

AMERICAN INSTITUTE OF MINING ENGINEERS.—At the annual business meeting held Feb. 16, officers of the council were elected as follows: President, D. W. Brunton, Denver, Colo.; Vice-Presidents, W. L. Saunders, New York, N. Y.; H. V. Winchell, St. Paul, Minn.; W. C. Ralston, San Francisco, Cal.; Secretary, R. W. Raymond, New York, N. Y.; Councilors, Alex. C. Humphreys, New York, N. Y.; Karl Ellers, New York, N. Y.; W. G. Miller, Toronto, Can.

ILLUMINATING ENGINEERING SOCIETY.—The regular meeting of the New York section will be held March 18, at the Engineering Societies' Building, 29 West 39th St., New York City, at 8.15 p. m. Two papers will be read: (1) "The Mathematical Theory of Finite Surface Light Sources," by Mr. Bassett Jones, Jr., and (2) "Illuminating the Editorial Offices of the New York 'World'," by Mr. A. J. Marshall.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The annual dinner will be given at the Hotel Astor, New York City, at 7 p. m., March 11. The special feature of the dinner relates to the close of the first quarter century of the institute's existence. There will be addresses by President L. A. Ferguson; Mr. J. M. Smith, President, Am. Soc. C. E.; Prof. Elihu Thomson; Mr. F. J. Sprague; Dr. A. C. Humphreys, President of Stevens Institute of Technology.

The regular monthly meeting will be held at the Engineering Societies' Building, 33 West 39th St., New York City, at 8 p. m., March 12. Mr. B. R. Shover, Electrical Engineer of the Indiana Steel Co., at Gary, Ind., will present a paper entitled "The Industrial Application of the Electric Motor, as Illustrated in the Gary Plant of the Indiana Steel Co.." Several men, well known in the manufacture of electrical machinery and steel products, will discuss the paper.